Massive Point-to-Point and On-Demand Air Transportation System Investigation

Phase II Self-Assessment Summary

- Technical Feasibility / Technology Requirements
- Operational Feasibility / Human Performance Requirements
- Economic Impact / Cost-Benefit Analysis

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and
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Concept PTP Premise

- **To handle the expected increase in air transportation demand along with looming airport/airspace gridlock requires a paradigm shift – a "transformation plan."**
  - Use more runways
  - Increase density of aircraft within given airspace
  - Automate processes
- **Increase NAS Payload Capacity:**
  - Facilitate and Incorporate Massive Use of Point-to-Point (PTP) and On-Demand Air Transportation between Non-Hub Airports
    - Broaden the number of nodes and connectors within the grid
    - Plan for a 300% payload (number of passengers/tons of cargo) capacity using a 500% aircraft (number of operating commercial aircraft) capacity
    - We have 5400 public use and ex-military airports from which to choose

Concept PTP Core Ideas

- **To Mechanize Concept PTP Requires Development of Technology to Enable Six Core Idea Sets:**

ATM Automation

1. **Airports: Provide New Airspace Design and Non-Towered Airport ATM Automation**
2. **Extended Terminal Area: Harness 4D FMS for Time-Based Approach/Departure**
3. **En Route: Use New Airspace Structure Featuring Sectorless Airspace, Self Separation, and/or Air-Ground 4D Trajectory Negotiation**
4. **Traffic Flow Management: Implement Distributed Command & Control with Greater Commercial Air Transport Collaboration**

Air Transportation Operations Automation

5. **Implement Greater TFM Collaboration and Flight Timing Control**

Advanced Avionics

6. **Accommodate Broader Aircraft Spectrum and Exploit Advanced Avionics Equipage**

- **To Integrate Core Ideas Requires Incorporation of CNS, Weather Information, and System Wide Information Management (SWIM) Infrastructure Advancements**

Self Assessment Questions Addressed

- Is Concept PTP Technically Feasible?
  - If so, what are the Technology Requirements?
- Is Concept PTP Operationally Viable?
  - If so, what are the Human Performance Requirements?
- Is Concept PTP Economically Beneficial?
  - If so, what does the Cost-Benefit Analysis show in terms of benefits and benefit-cost ratio?

Issue of Technical Feasibility

- Question: If we provide more potential capacity by increasing the number of airports and runways used, is it possible to safely pack 400% more aircraft into the airspace leading to and from those runways?
  - If we keep 1000 ft vertical and 3 nmi longitudinal spacing requirements, can we reduce lateral spacing requirements to under 0.6 nmi (3600 ft)?
- Hypothesis: We think so, by harnessing the capabilities of 4D FMS, ADS-B, RNP, ATM automation, and FMS-ATM integration via data link.

MSP Airspace w & w/o FMS

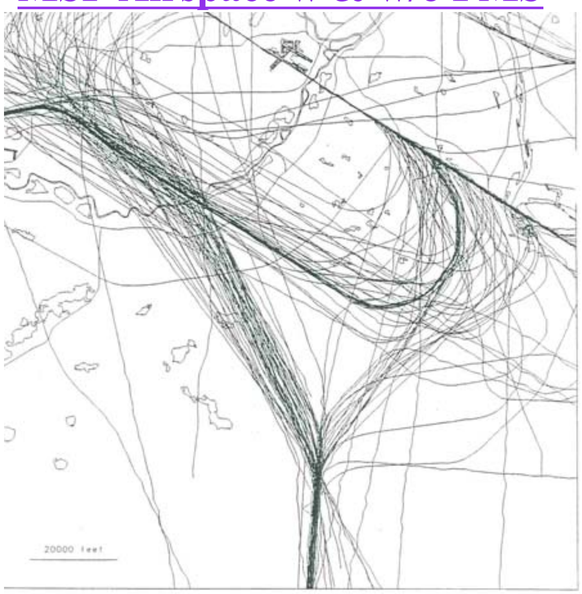


Figure 2.2 Northwest Airlines A320 Arrivals to Runway 29L, 10–30 May, 1992

Lateral Distribution for FMS a/c at MSP

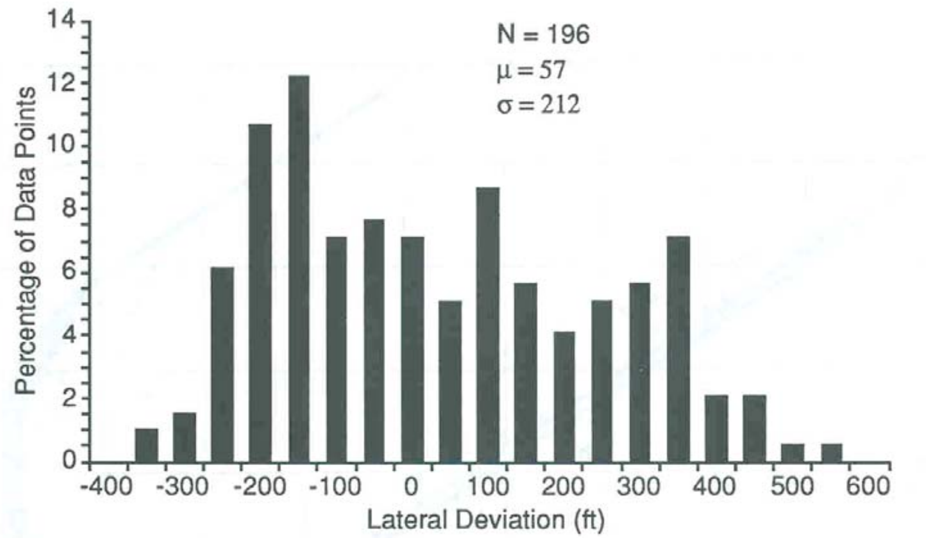
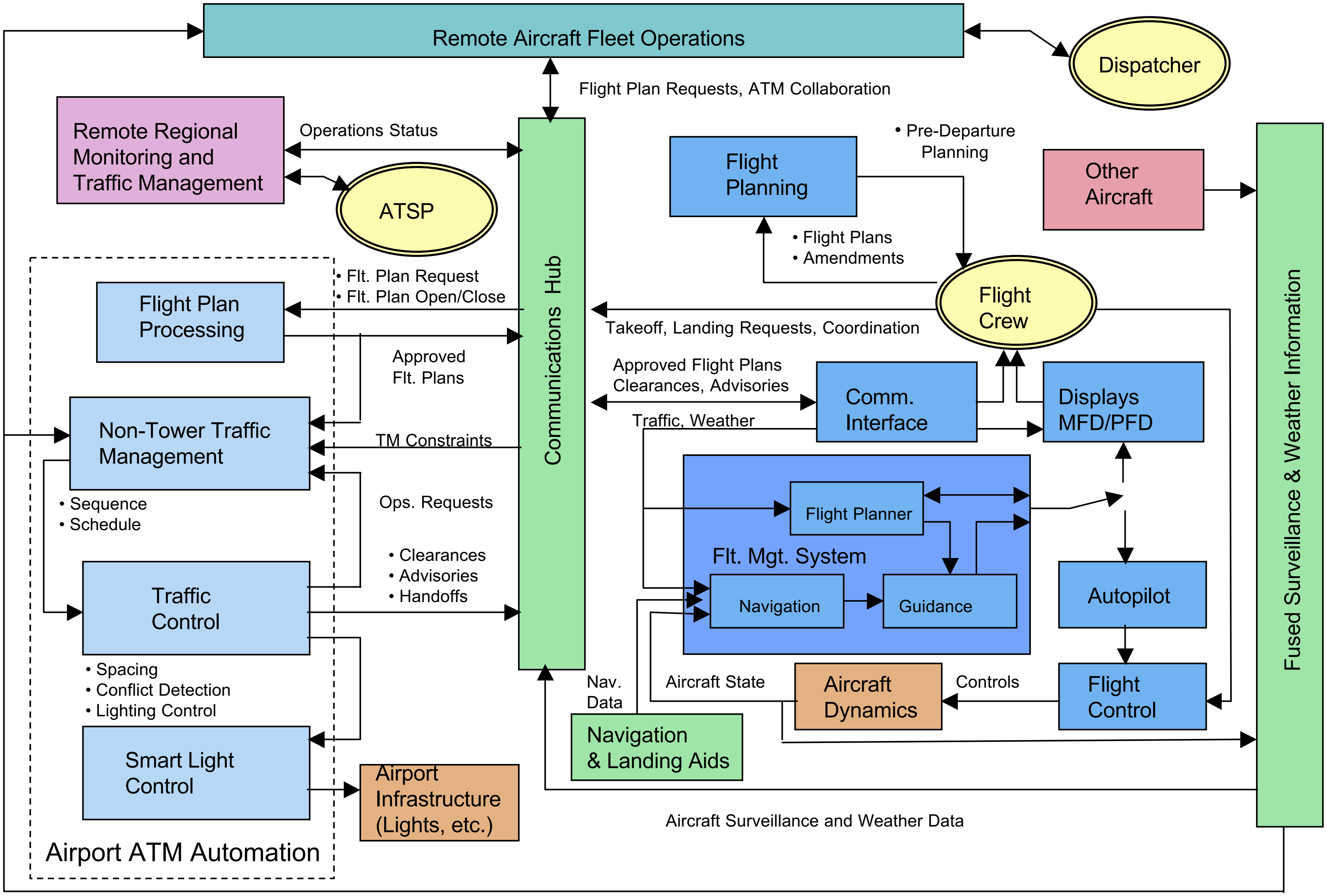


Figure 3.5 Distribution in A320 lateral deviations, downwind segment

- We need to develop and test the technology to validate this hypothesis

Functional Architecture Example: Integrated Airport ATM - Flight Deck Automation



Functional Description Example: Airport ATM Automation

Input

Quantity	Source
▪ Aircraft state	- Fused surveillance
▪ Aircraft intent	- Downlink, broadcast, or derived
▪ Airport weather measurements	- ASOS
• Vicinity winds aloft	- Weather provider
▪ Status of surrounding ATM/airspace	- Regional ATM

Function Steps

- Determine airport weather, runway configuration and patterns;
- Update traffic scenario – note new aircraft and aircraft dropped;
- Compute runway conditions advisory for new aircraft;
- Obtain or sense aircraft intent – land, depart, fly-over, touch-and-go, etc.;
- Compute estimated aircraft trajectory – both new and continuing traffic;
- Determine takeoff/landing sequence and spacing requirements;
- Prepare sequence, spacing, and immediate traffic advisory messages;
- Compute landing and taxi light signals for landing or surface traffic;
- Monitor traffic for potential loss of separation/conflicts;
- Compute conflict avoidance advisory if necessary;
- Automatically open/close flight plans based upon takeoff or runway exit;
- Prepare status information for regional ATM coordination.

Output

- Airport operations status including runway in use, ATIS, winds aloft for uplink
- Broadcast and uplink airport conditions, sequence, spacing and traffic advisory messages
- Runway and taxi-way lighting signals to smart lighting system
- Flight plan open/close and airport status message for nearby or remote ATM

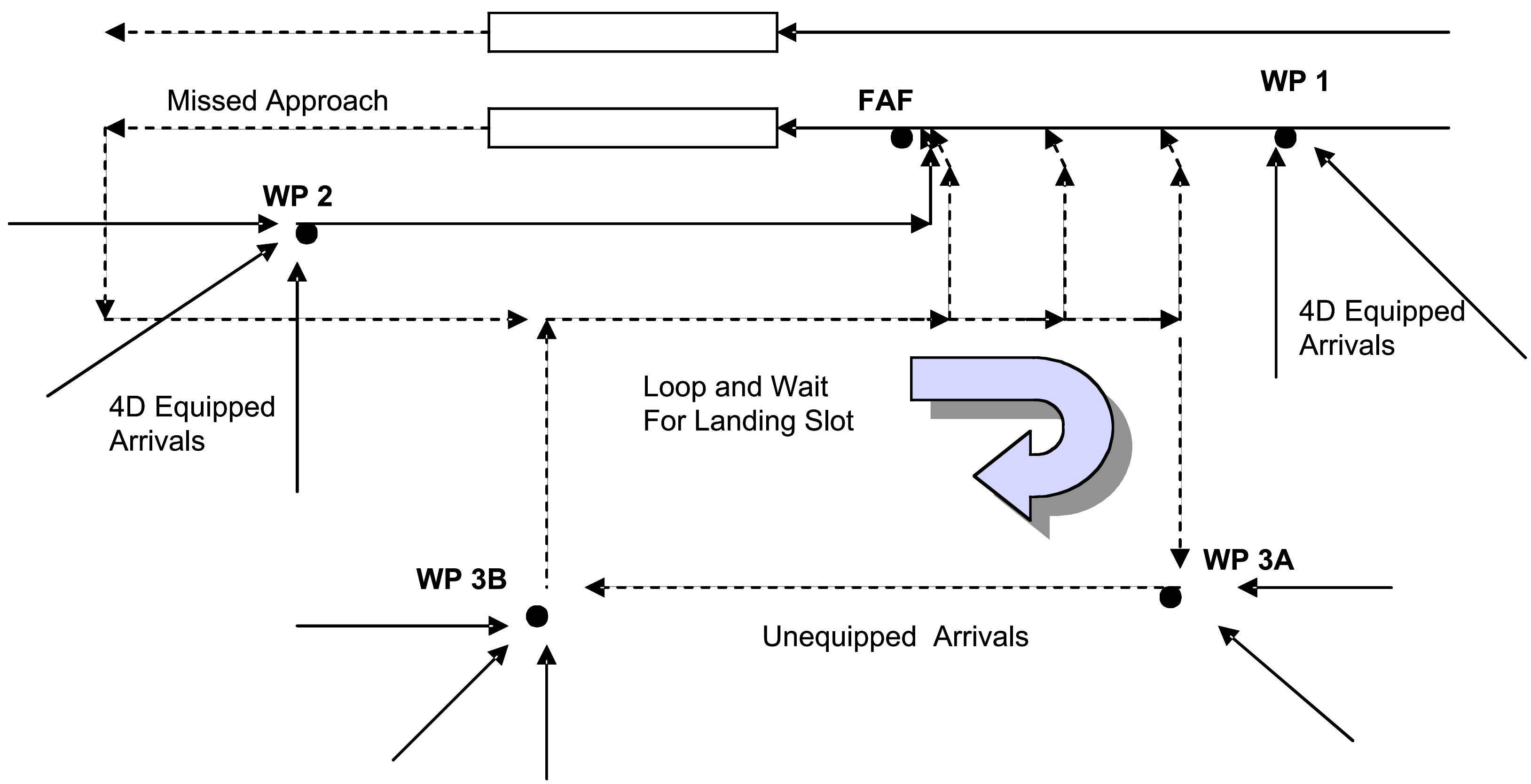
Technology Performance Requirements Example: Avionics

Component	Relevant Performance Measures	Estimated Range
FMS - Navigation	Position estimation accuracy/RNP	30 m
FMS - Trajectory Predictions	Path definition accuracy Computation speed / delay Number of trajectories to store/predict	30 m growing to 600 m in 20 minutes; 4 trajectories every 1 sec
FMS – Precision Guidance to Negotiated Trajectory Contract	Path steering accuracy Time of arrival control accuracy Speed control accuracy	100 m lateral; 10 m vertical; 5 sec RTA accuracy; 2 kt
Self Separation Assurance – Autonomous Operations Planner	Number of other aircraft to store/predict/de-conflict Path definition accuracy Computation speed / delay Number of trajectories to store/predict	TBD
Terminal Area Merging and Self-Spacing - CDTI	Spacing control accuracy Speed control accuracy	600 m; 2 kt
Trajectory Negotiation Datalink	Speed of communication Message transmission reliability	0.1 sec; 9 9s reliability; see Tables 1-11, 1-12

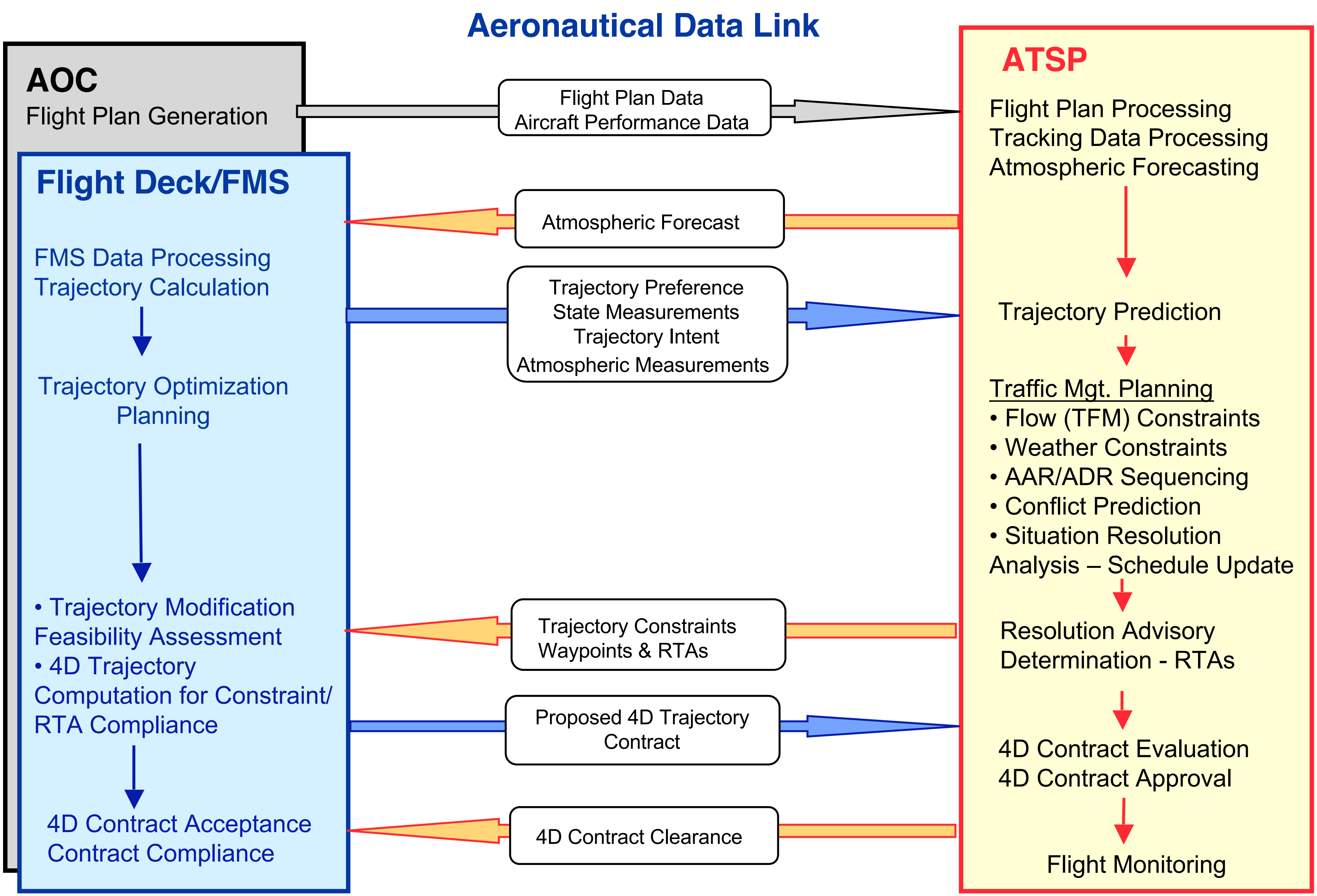
Technology Requirement: Terminal Area Airspace Design to Facilitate Time-Based ATM

Exploit 4D FMS and place anchor points to facilitate conflict free approach and departures

- Space design and procedures accommodate mixed equipage aircraft
- Reduced Protected Airspace Zone (PAZ) about Types A and B aircraft accommodates greater densities and reduced separations.



Technology Requirement:
ATM-FMS 4D Trajectory Negotiation and Contracting Process



Technology Requirements: Operational Needs/Capabilities

Example of Required ATM Automation for Enabling 4D Trajectory Negotiation

Operational Need/Capability - 4D Clearance Generation	When	Existing, Planned, or Gap	Comments
1. High fidelity trajectory modeling	2006	Planned – FAA	Basis of trajectory-based ATM
2. 4D trajectory optimization	2007	Planned R&D	Minimize operating cost
3. Multiple RTA determination	2009	Gap	Avoids crossing conflicts
4. Error ellipsoid (PAZ) calculation/RTSP	2010	Planned R&D	Provides separation constraint buffer size
5. Other constraint computation			
- Weather	2015	Planned R&D	Dynamic convective cell prediction
- Wake calculation and display	2015	Planned R&D	Type aircraft and flight environment dependent
- Noise abatement	2009	Planned R&D	Community dependent
- SUA restrictions	2009	Planned - FAA	Dynamic status
6. Constraint avoidance trajectory adjustment	2010	Gap	Collective avoidance of traffic, weather, SUA, noise constraints
7. Reference trajectory compilation and uplink of RTA	2012	Gap	Basis of 4D trajectory negotiation

Summary of Operational Needs Status

Operational Needs Identified and Divided into 123 Components

- **Six Core Idea Distributions**
- **ATM Automation, Fleet Operator Automation, Flight Deck Avionics, and CNS / Weather Information Infrastructure**

Needs (Capabilities) Status Assessed Per Gap, Existing R&D, Planned Technology/ Implementation, and Existing/Fielded Technology

Existing, Planned, or Gap	ATM Automation	%	Fleet Operator Automation	%	Flight Deck Avionics	%	CNS / Wx Information	%
Existing Technology	2	1.6	0		15	12.2	1	0.8
Planned Technology	10	8.1	4	3.3	3	2.4	16	13.0
Existing R&D	23	18.7	1	0.8	7	5.7	17	13.8
Gap	17	13.8	3	2.4	3	2.4	1	0.8
Total Components	52	42.3%	8	6.5%	28	22.8%	35	28.5%

Roadmap and Transition Plan Developed to Conduct R&D Leading to Implementation, Testing, and Fielding to Meet These Needs

Technical Feasibility Status and Challenges

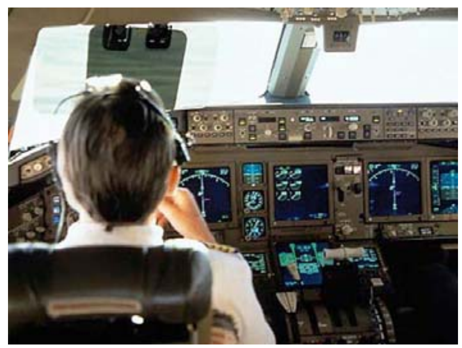
- **Concept PTP seems to be technically feasible**
  - **Chief technical challenge is determining how to operate up to 500% of today's commercial transport aircraft within an extended terminal area serving multiple airports**
  - **Required system divided into 123 technology components**
  - **Each component defined in terms of technical and functional architectures, required performance needs, capability needs status, and transition roadmap**
- **Next step is to model and simulate the envisioned system**
  - **Develop representative automation algorithms**
  - **Parameterize key variables**
  - **Conduct tradeoff studies**
  - **Assess potential capacity, operational flexibility, and safety metrics**

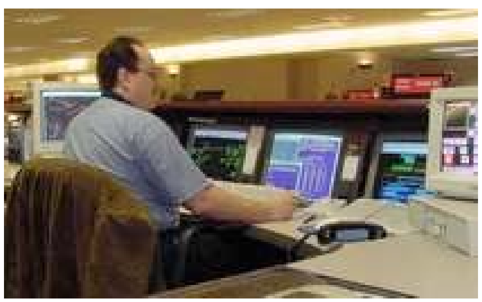
Self Assessment Questions Addressed

- Is Concept PTP Technically Feasible?
  - If so, what are the Technology Requirements?
- Is Concept PTP Operationally Viable?
  - If so, what are the Human Performance Requirements?
- Is Concept PTP Economically Beneficial?
  - If so, what does the Cost-Benefit Analysis show in terms of benefits and benefit-cost ratio?

Issue of Operational Feasibility

- **<u>Question:</u> If we provide a suite of new PTP technologies and procedures to the air traffic controllers, pilots, and dispatchers, can they effectively carry out their jobs in safely enabling future increases in NAS aircraft flight operations?**
- **<u>Hypothesis:</u> We think so, by making sure that the human element is properly addressed in the design and ultimate implementation of the concept**





- **We need to flesh out the human performance issues to validate this hypothesis**

Human Performance Requirements Analysis: *Approach*

- **Identify Potential Issues**
  - Discussions held with relevant players in the current non-PTP operations environment.
  - High level analysis by human factors professionals with relevant operational experience, was performed
- **Collect data**
- **Online questionnaire used to gain feedback on the estimated difficulty from current relevant players:**
  - Pilots
  - Controllers
  - Dispatchers

Human Performance Requirements Analysis: *Approach*

- **Identify Interface Issues**
  - Hypothetical Interface for Standard Equipped Aircraft
  - Hypothetical Interface for Well Equipped Aircraft
  - Hypothetical ATM Interface
  - Fleet Operators (Dispatch)
  - Decision Support Tool interoperability
  - User trust in automation
- **Operational Issues at PTP Non-tower Airports**
  - IMC holding, arrivals, departures, negotiation, NORDO
    - Standard Equipped Aircraft
    - Well Equipped Aircraft
    - ATM and ATC
  - Miscellaneous
    - 4-D Nav Time constraints, UAVs, Tilt rotors...
  - Game playing

Human Performance Requirements Analysis: *Approach*

- **Subject Matter Expert Survey**
  - SurveyMonkey.com
  - Developed, tested, revised
    - Participant's background
    - Knowledge of PTP enabling technologies
    - Estimates of difficulty relative to current
    - Open ended
  - Population
    - 101 completed survey (214 started)
    - 9 ATCSs, 29 pilots, 45 dispatchers
- **Informal Discussions**
  - with relevant non-PTP players
    - Pilots
    - Controllers
    - Dispatchers
    - System and software engineers
    - Other human factors engineers
  - Occurred though out the year
  - Aimed at high level issues

Human Performance Requirements Analysis: *Results*

- **Given conservative nature of aviation - results positive**
- **Pilots often reported a reduction in difficulty**
- **ATCSs & dispatchers perceived slightly higher difficulty**
- **Example:**
  - **"Compared to current system operation, the operational difficulty with making approaches and departures at a nontowered PTP airport in IMC would be:"**

		Response Percent	Response Total
+3 Maximum increase in difficulty		3.4%	1
+2		6.9%	2
+1		17.2%	5
0 No change in difficulty		17.2%	5
-1		20.7%	6
-2		**31%**	**9**
-3 Maximum decrease in difficulty		3.4%	1
		Total Respondents	**29**

Pilot Feedback

		Response Percent	Response Total
+3 Maximum increase in difficulty		12.5%	1
+2		0%	0
+1		**50%**	**4**
0 No change in difficulty		12.5%	1
-1		25%	2
-2		0%	0
-3 Maximum decrease in difficulty		0%	0
		Total Respondents	**8**

Controller Feedback

- **Challenges:**
  - **Identify ways to examine the future**
  - **Find and observe first approximations**

Self Assessment Questions Addressed

- Is Concept PTP Technically Feasible?
  - If so, what are the Technology Requirements?
- Is Concept PTP Operationally Viable?
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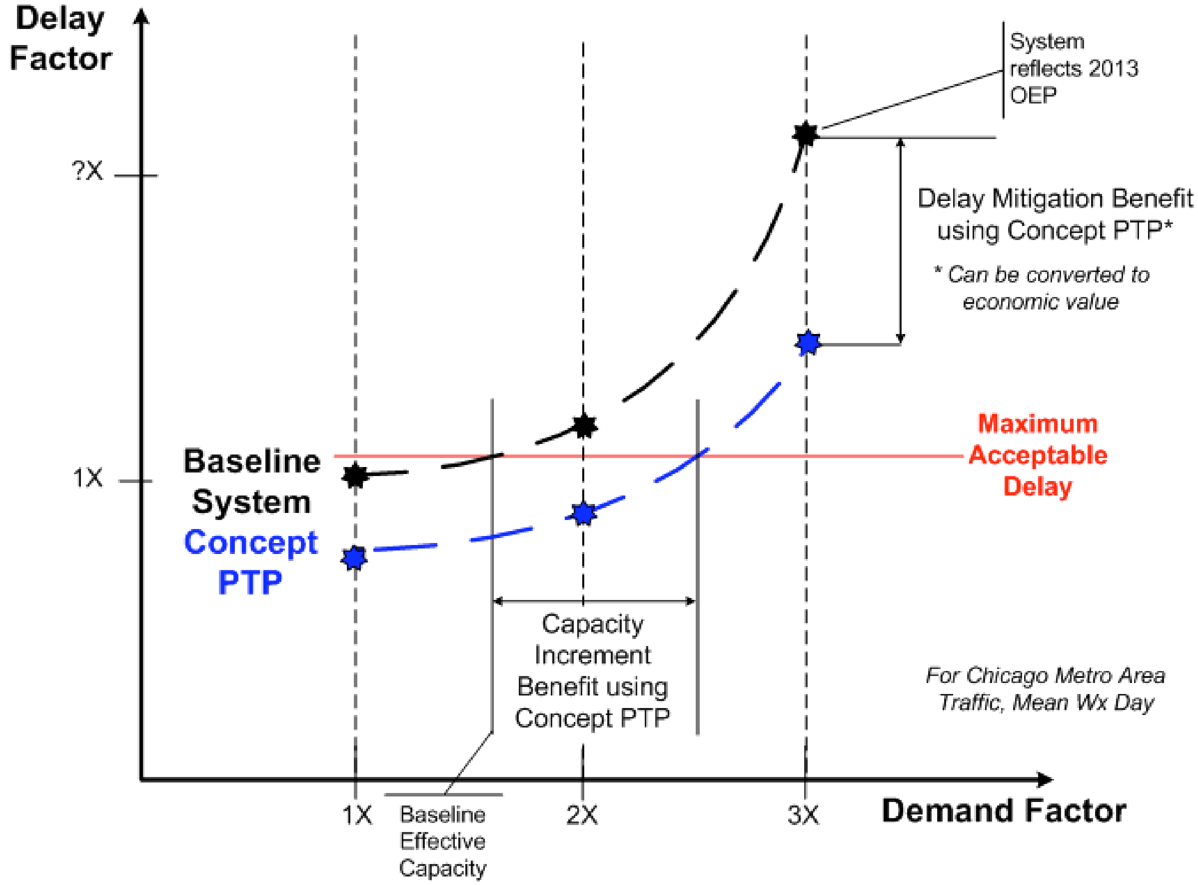
  - If so, what does the Cost-Benefit Analysis show in terms of benefits and benefit-cost ratio?

Issue of Economic Impact

- **Question:** **If the PTP system works as hoped, is there a feasible PTP business case proposition to be made to the aviation stakeholders?**
- **Hypothesis:** **We think so, due to the significant benefits provided by Concept PTP relative to a 2020-timeframe NAS problem.**



- **We need to quantify the operational PTP costs and benefits to validate this hypothesis**

Metrics

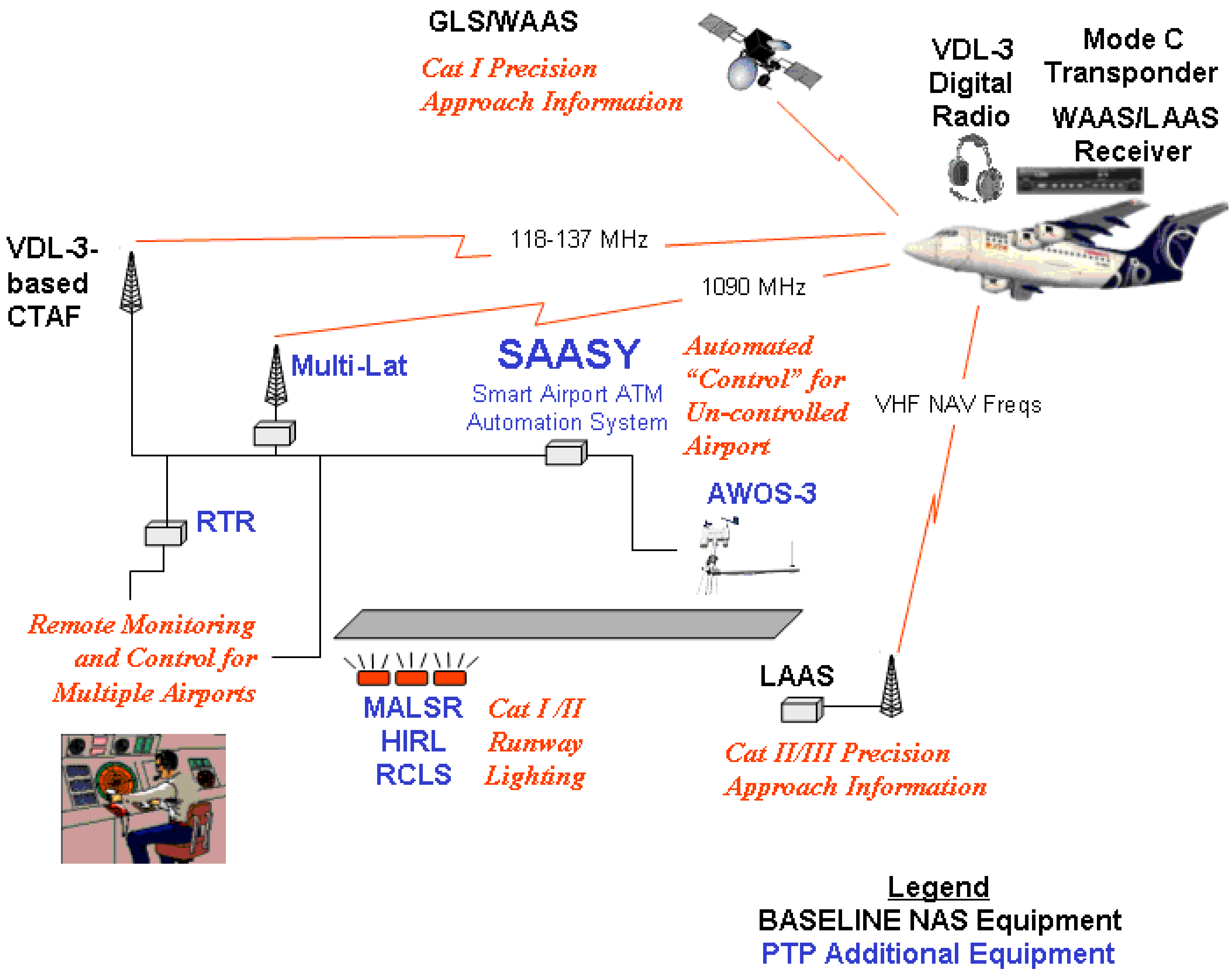
- Average aircraft delay in terms of:
  - Actual gate-in time - Scheduled gate-in time
  - Actual total flight time – Unobstructed flight time
- Regional effective capacity: throughput for a given maximum acceptable average delay value (e.g., 14 minutes)
- Maximum number of aircraft operations per peak hour in IMC and VMC (for the selected region under study)
- Annualized additional infrastructure system costs; and
- Concept PTP auxiliary airport system benefit-to-cost ratio

Sample Concept PTP Benefit Mechanisms Specification

Capabilities	Direct Impacts	Direct Impact Metrics	Benefit Impacts	Benefit Impact Metrics
• Surrounding small airport surveillance and air traffic control automation system with new nontowered airport procedures	• Pilots not required to follow one-in, one-out IFR procedures	• Number of simultaneous aircraft within 5 nm of airport	• Increased airport capacity	• Average number of IFR aircraft arrivals per peak hour
	• Improved pilot awareness of surrounding traffic	• Pilot response time to identify proximate traffic		• Average number of arrival delays per peak hour
	• Reduced level of ATC staffing and equipment to support equivalent IFR ops	• Number of ATC Specialists required to support typical IFR traffic levels	• Increased airport safety	• Accident rate within 5 nm of nontowered airports
			• Reduced airport ATC costs for a given level of ATC service	• FAA cost savings to support IFR operations

PTP Core Idea 1:
Automated Airports

- **Nominal Nontowered/Towered Airport Architecture:**



PTP Benefits and Cost Assessments

- Regional Benefits and Cost Assessments
  - Chicago Metro Area Regional Benefits Assessment
  - Chicago Metro Area Regional Cost Assessment
  - Cost-Benefit Assessment
- NAS-wide Benefits Assessments
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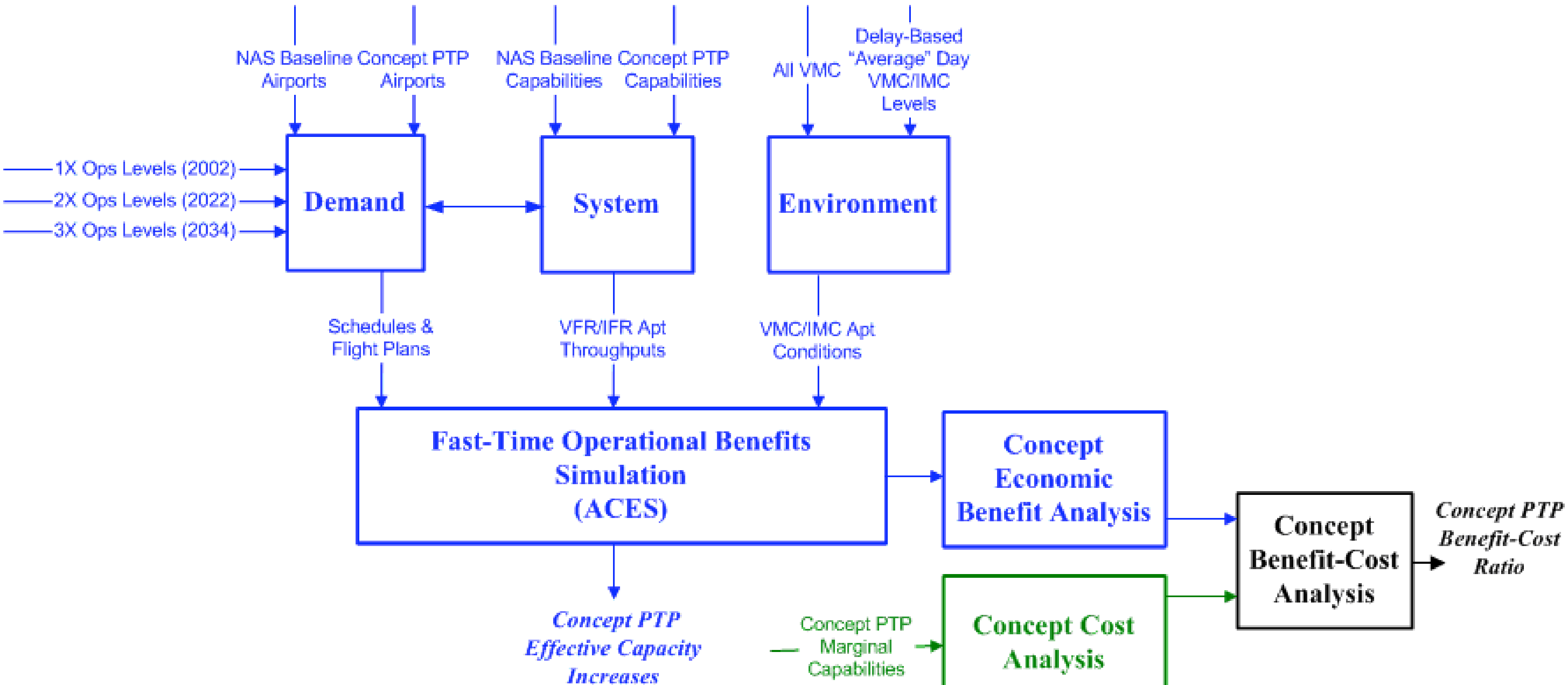
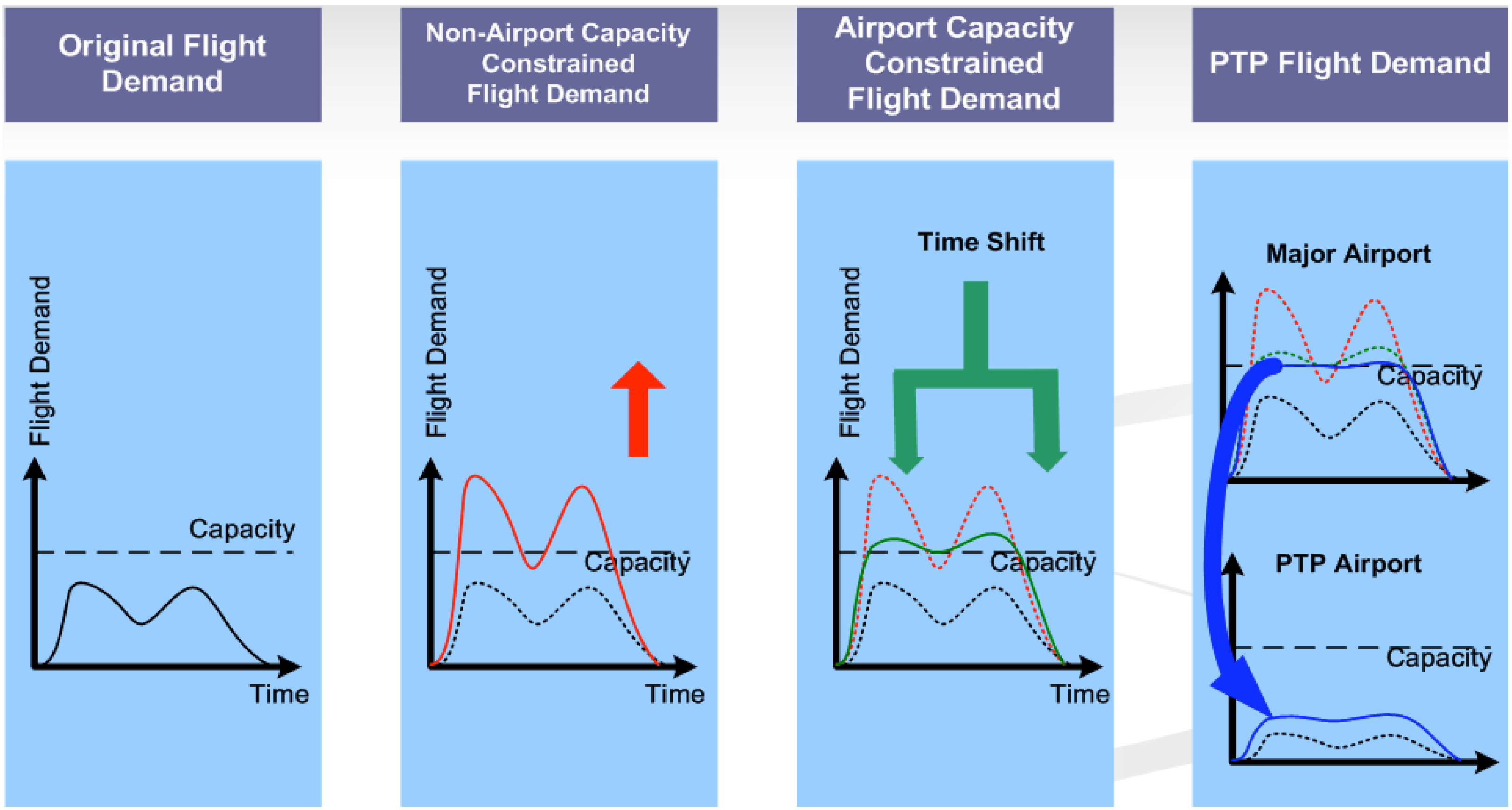
Approach:
Regional Benefits Overview

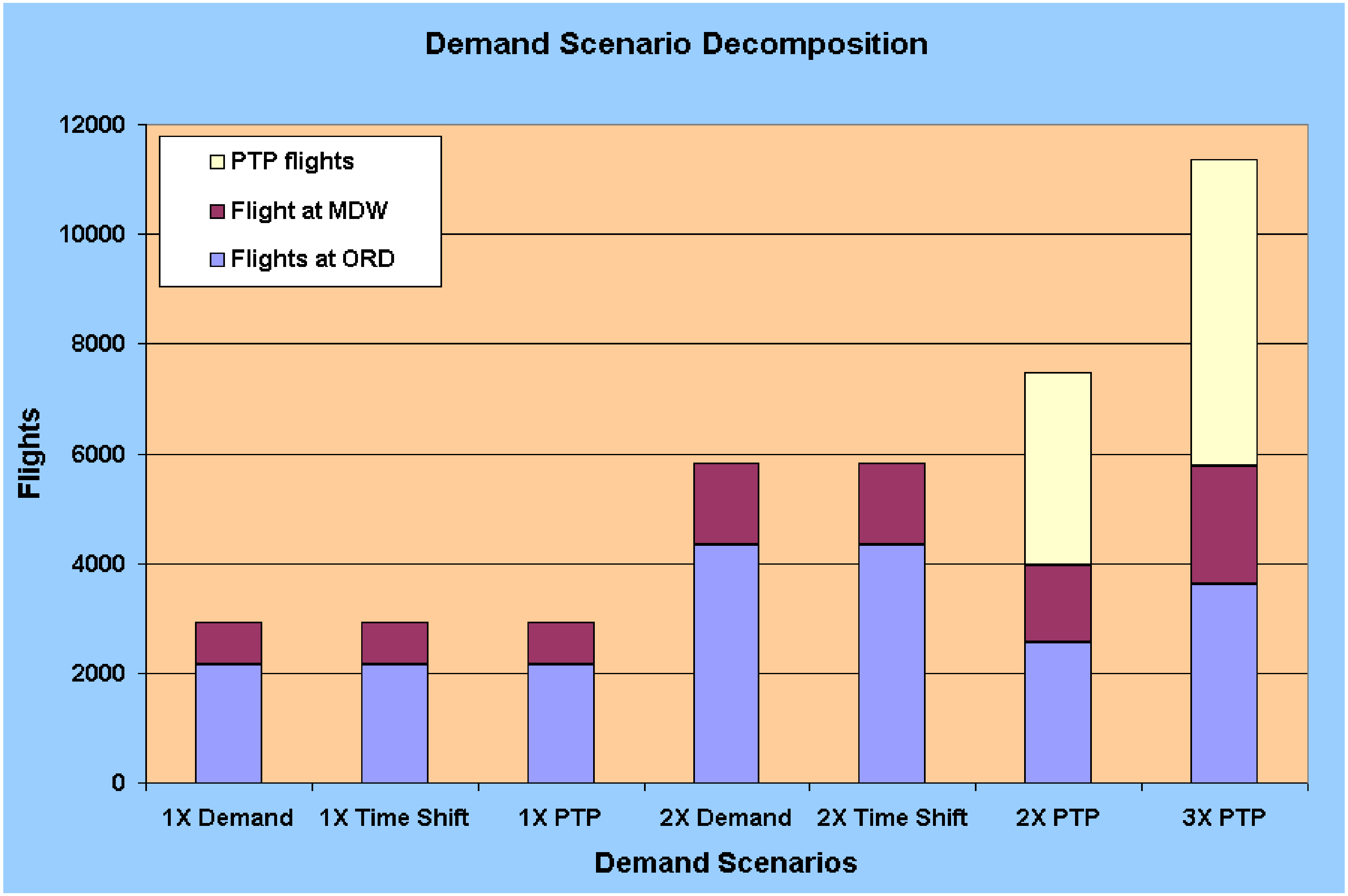
- **Concept PTP Self-Assessment:**



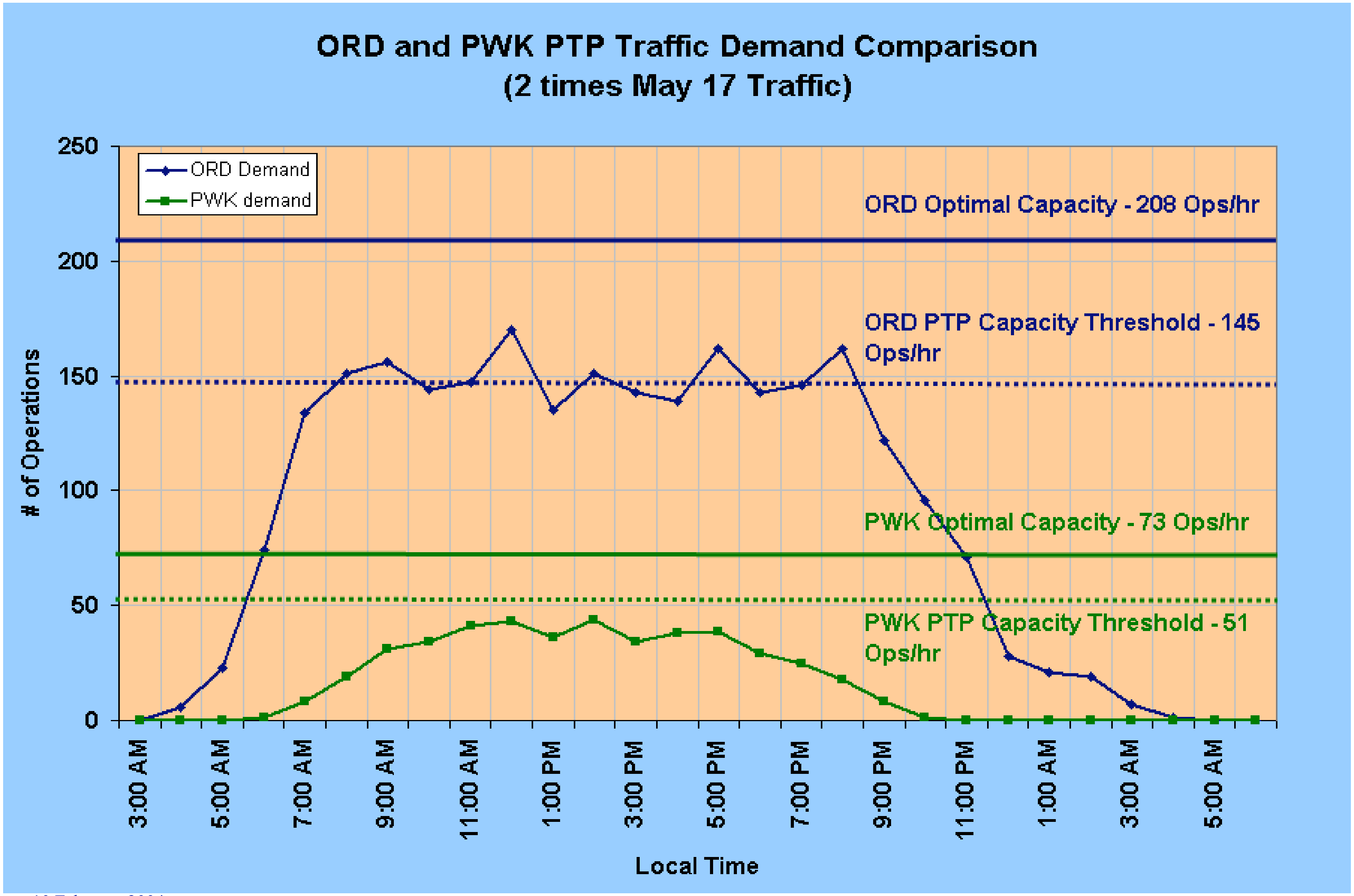
Multiple Flight Demand Scenarios



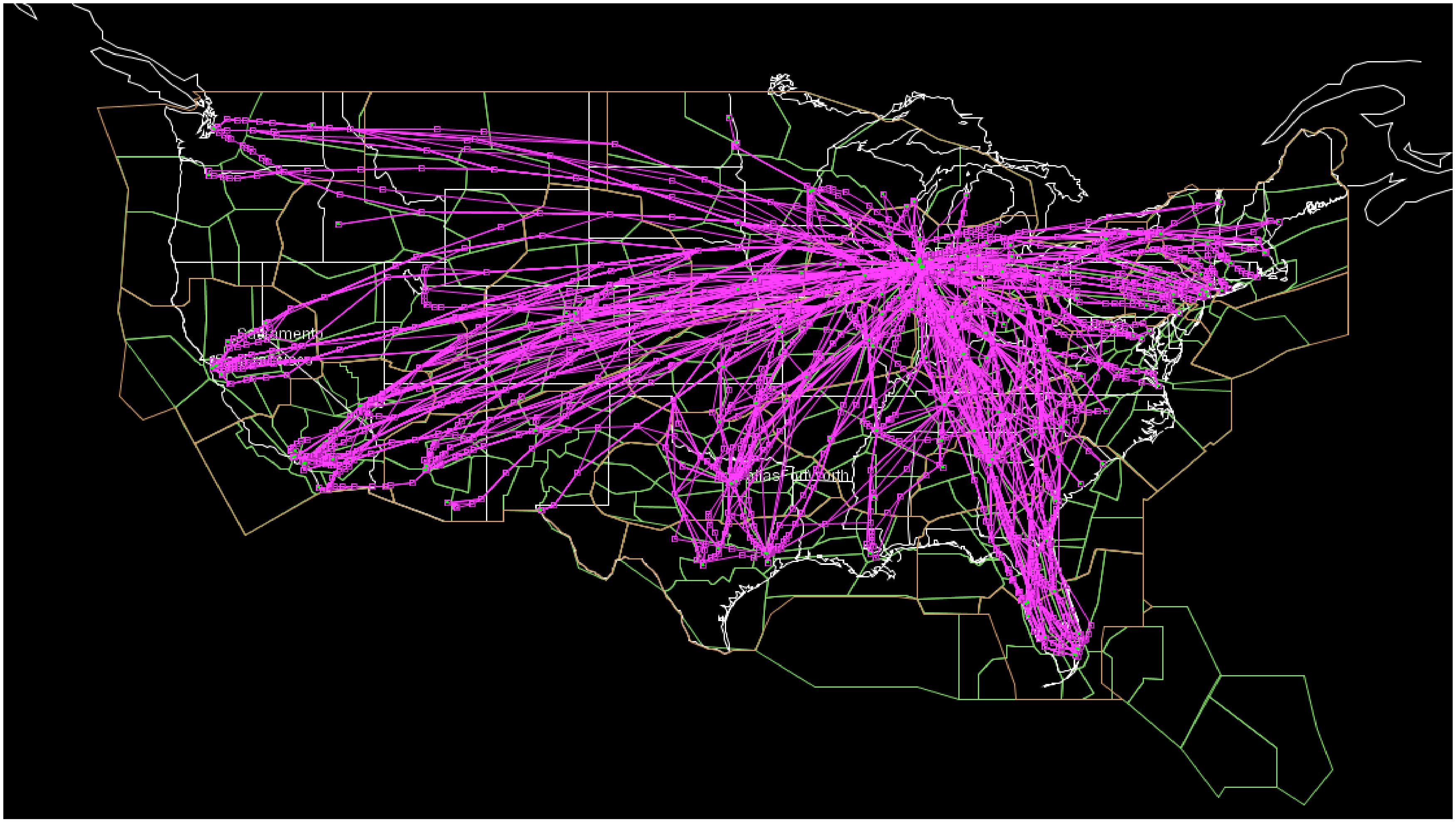
Flight Demand Scenario Comparison



Example 2X PTP Demand Scenario

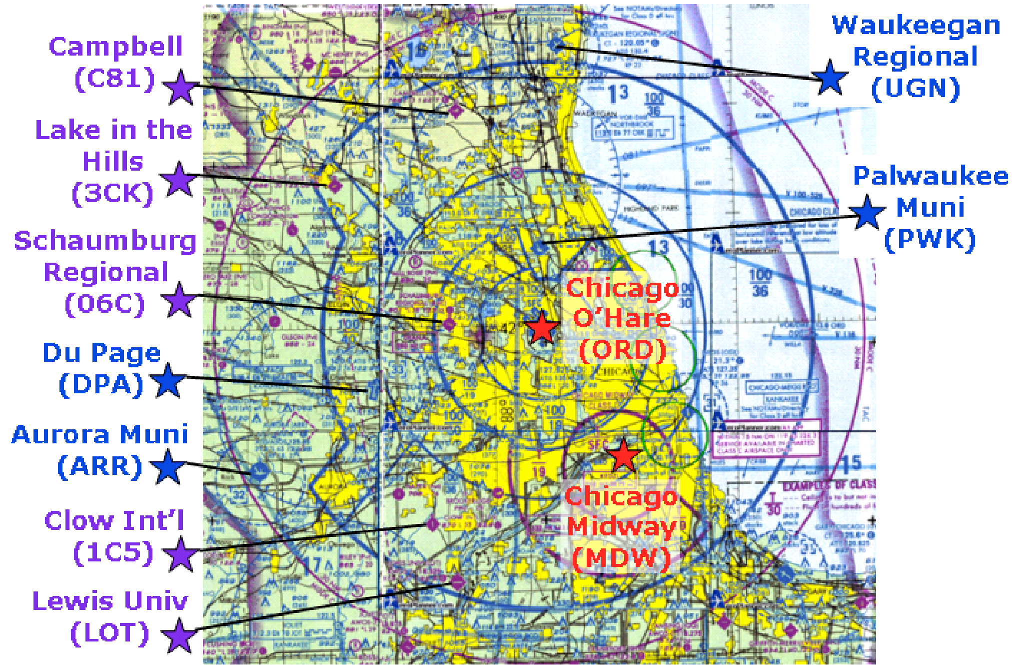


Flight Plans for the Chicago Metro Area Traffic



Approach:
System Generation

Baseline System



Future Concept PTP System

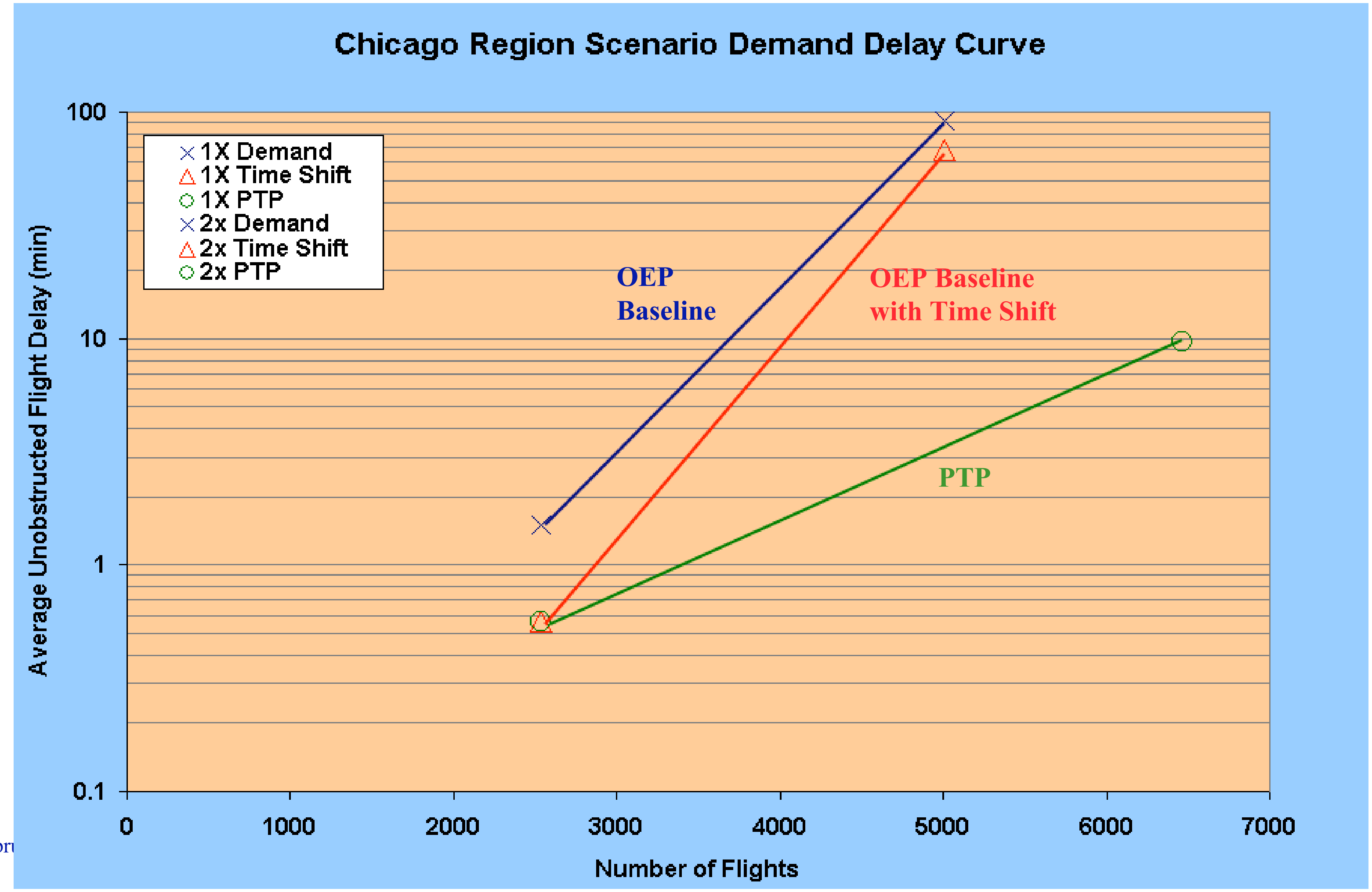
Approach:
System Generation

- **Sources: Airport Capacity Benchmark 2001, "Handbook Method" (FAA AC 150/5060-5), Terminal Area Forecasts**

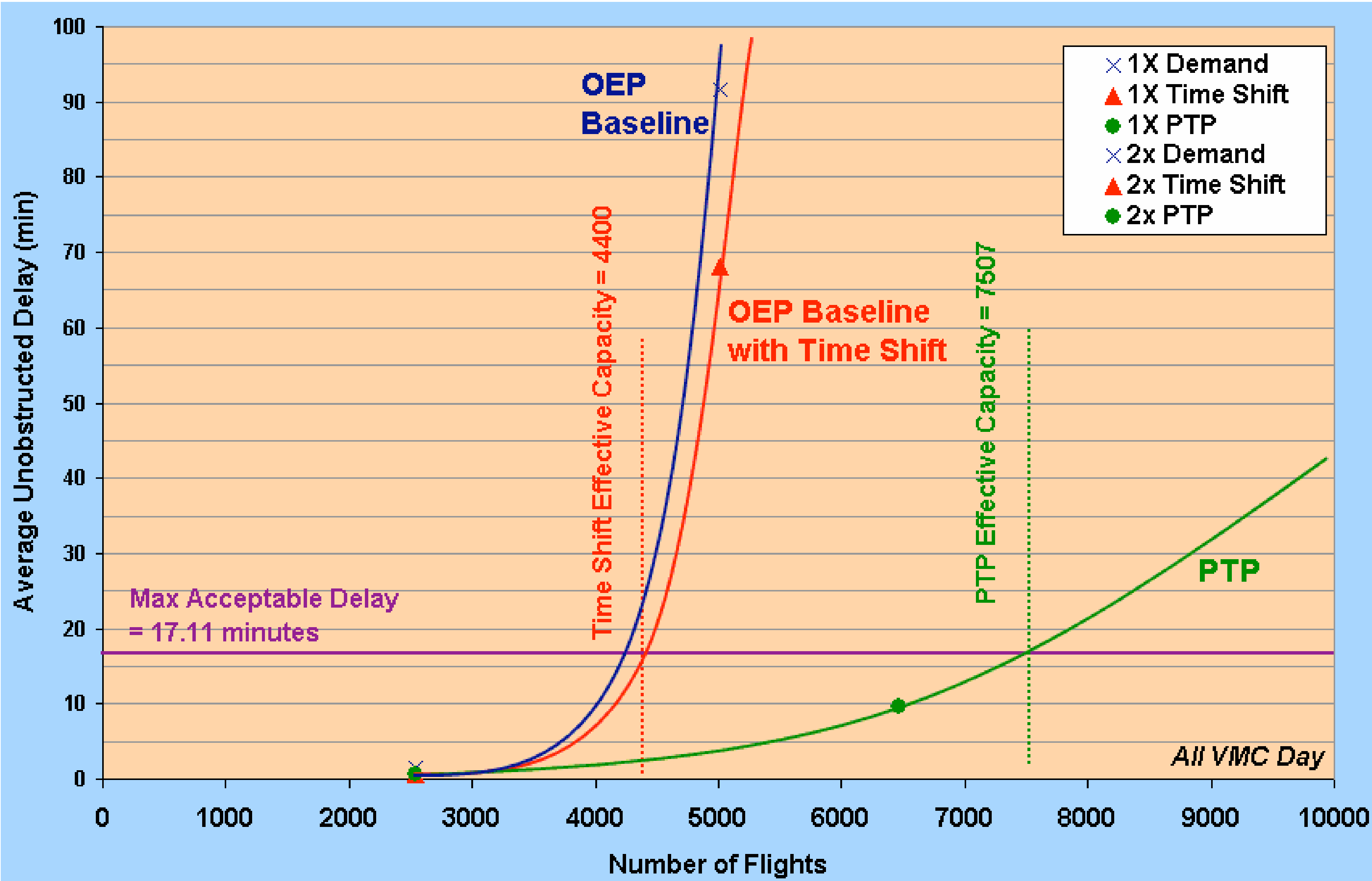
Airport Designator	Airport Name	Towered, Commercial Status	Nominal VFR Capacity (Ops/Hr)	Nominal IFR Capacity (Ops/Hr)	Nominal GA (Ops/Hr)
ORD	Chicago O'Hare International Airport	Towered/ Commercial	213	179	NA (4)
MDW	Chicago Midway	Towered/ Commercial	125	60	NA (9)
PWK	Palwaukee Muni	Towered/ Noncommercial	77	56	26
DPA	Du Page	Towered/ Noncommercial	121	56	28
UGN	Waukegan Regional	Towered/ Noncommercial	77	57	9
ARR	Aurora Muni	Towered/ Noncommercial	77	57	11
C81	Campbell	Nontowered/ Noncommercial	77	56	2
06C	Schaumburg Regional	Nontowered/ Noncommercial	74	57	7
LOT	Lewis University	Nontowered/ Noncommercial	74	57	7
1C5	Clow International	Nontowered/ Noncommercial	63	56	5
3CK	Lake in the Hills	Nontowered/ Noncommercial	63	56	5

Chicago Metro Area Benefit Results

- **Using:**
  - **Chicago Metro Area Demand and Capacity Levels**
  - **ACES (incl. en route queuing, CD&R, no AOC cancellations)**
  - **VMC all day**
  - **Delays based on unobstructed flight times, not schedule data**



Effective Capacity Estimation Assuming Exponential Demand-Delay Relationship



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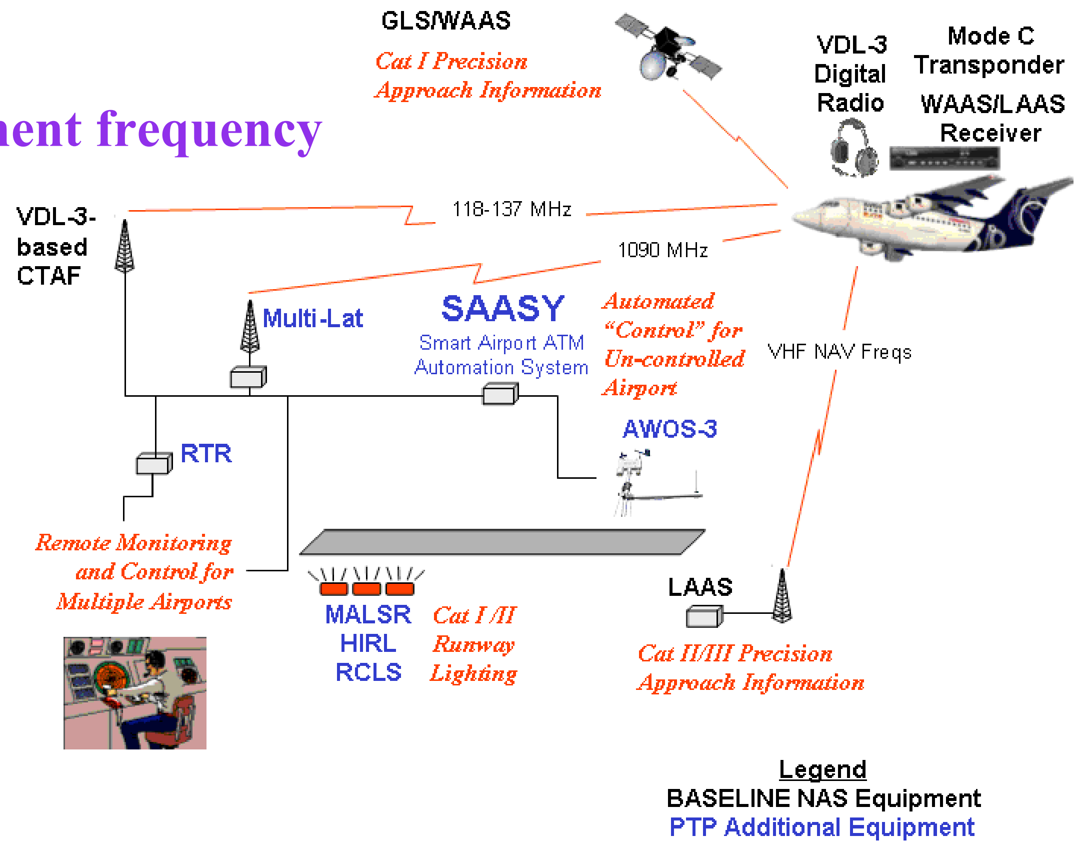
Approach:
Cost Generation

- **Goal: Determine ROM marginal PTP Chicago Area costs**
  - **Breakdown into cost components**
    - › **Assumed in System Baseline (i.e., OEP 2013)**
      - E.g., GLS/WAAS
    - › **Marginal PTP Costs**
      - E.g., SAASY Automation
    - › **Other**
      - Terminal buildings
  - **Roll up based on component frequency**



Approach:
Cost Generation

• Chicago Area Infrastructure Assumptions:

Chicago Metro Area Airports

	Commercial		*Towered*				*Non-Towered*			
	ORD	MDW	PWK	DPA	UGN	ARR	LOT	06C	1C5	C81
NAS Equipage										
RCO				X						
RTR	X(5)	X	X(2)	X	X(2)	X	X	X	X	X
Multi Lat		X	X	X	X	X	X	X	X	X
ATM Automation			X	X	X	X	X	X	X	X
MALSR	X	Lights	X	X	X	X	X	X	X	X
HIRL	X	X	X	X	X	X	X	X	X	X
RCLS	X	X	X	X	X	X	X	X	X	X
LAAS	X					X				X
RVR	X	X		X						
AW/SOS	ASOS	ASOS	ASOS	ASOS	ASOS	ASOS	AWOS-3	AWOS-3	AWOS-3	AWOS-3
CTAF	UNICOM	UNICOM	CTAF	UNICOM	CTAF/UNI	CTAF/UNI	CTAF/UNI	CTAF	CTAF	CTAF/UNI
VDL-3 CTAF	X	X	X	X	X	X	X	X	X	X
GLS/WAAS	X	X	X	X	X	X	X	X	X	X

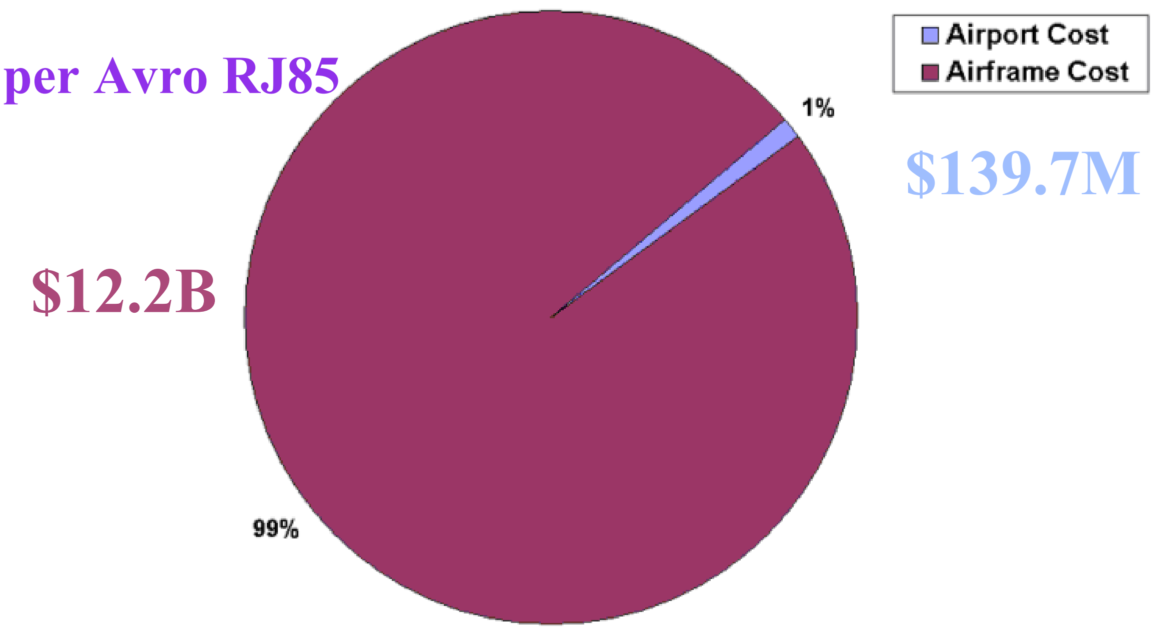
Other										
FireFighting	ARFF/IndE	ARFF/IndD								
Terminal Buildings	X	X								

Aircraft Equipage	
Mode C Transponder	X
VDL-3 Digital Radio	X
GLS/WAAS Nav Radio	X
LAAS Nav Radio	X

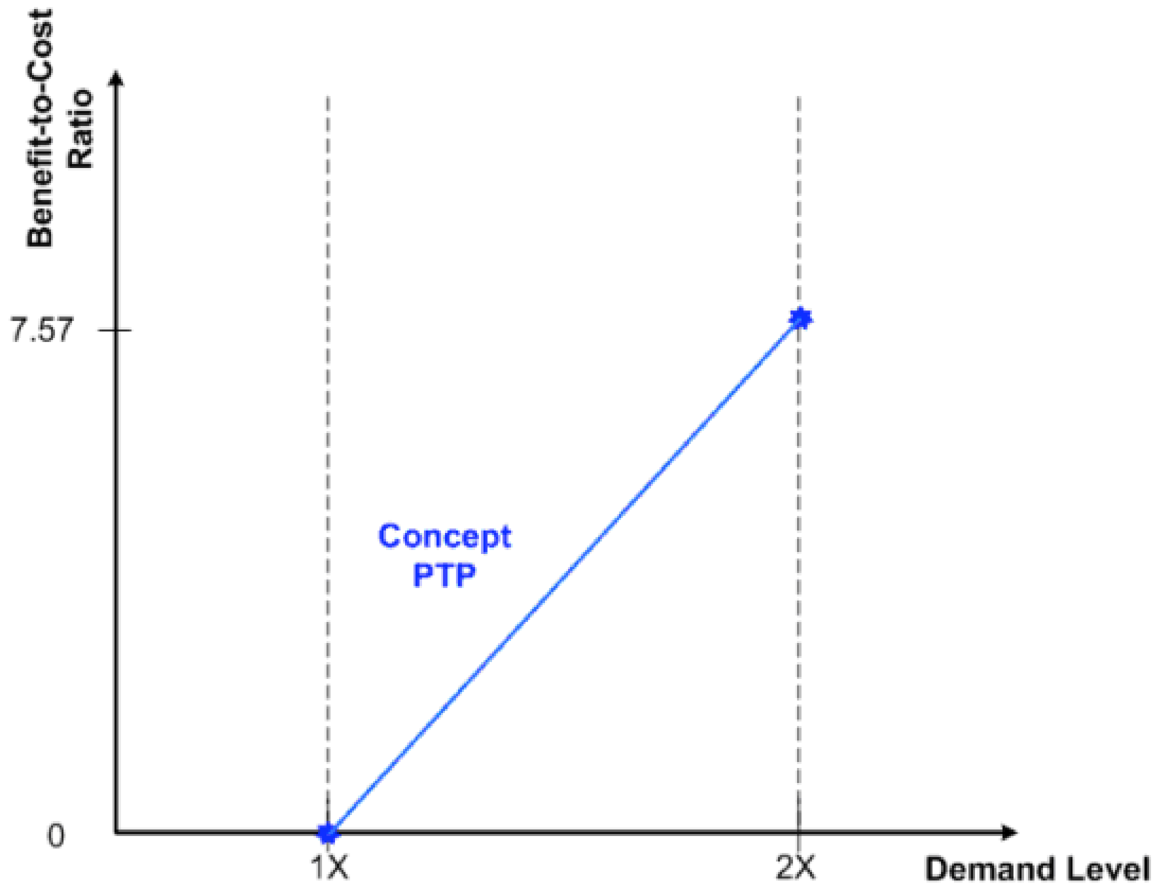
Exists X
Forecasted to Exist X
PTP Additional Item X

Approach:
Cost Analysis

- **Assumptions:**
  - **2X Demand Scenarios (OEP Timeshift vs. PTP)**
  - **20 Year Economic Life**
  - **2003 $**
- **Airport Costs:**
  - **$108.8M ATM Automation**
  - **$14.0M Multi-lateration**
  - **$16.7M Other**
- **Airframe Costs:**
  - **$25.23M Acquisition per Avro RJ85**



Approach:
Cost-Benefit Analysis



- **Based on daily delay mitigation benefit vs. equivalent-daily life cycle costs**
- **Caveats:**
  - **Ignoring direct and indirect revenue benefits**

PTP Benefits and Cost Assessments

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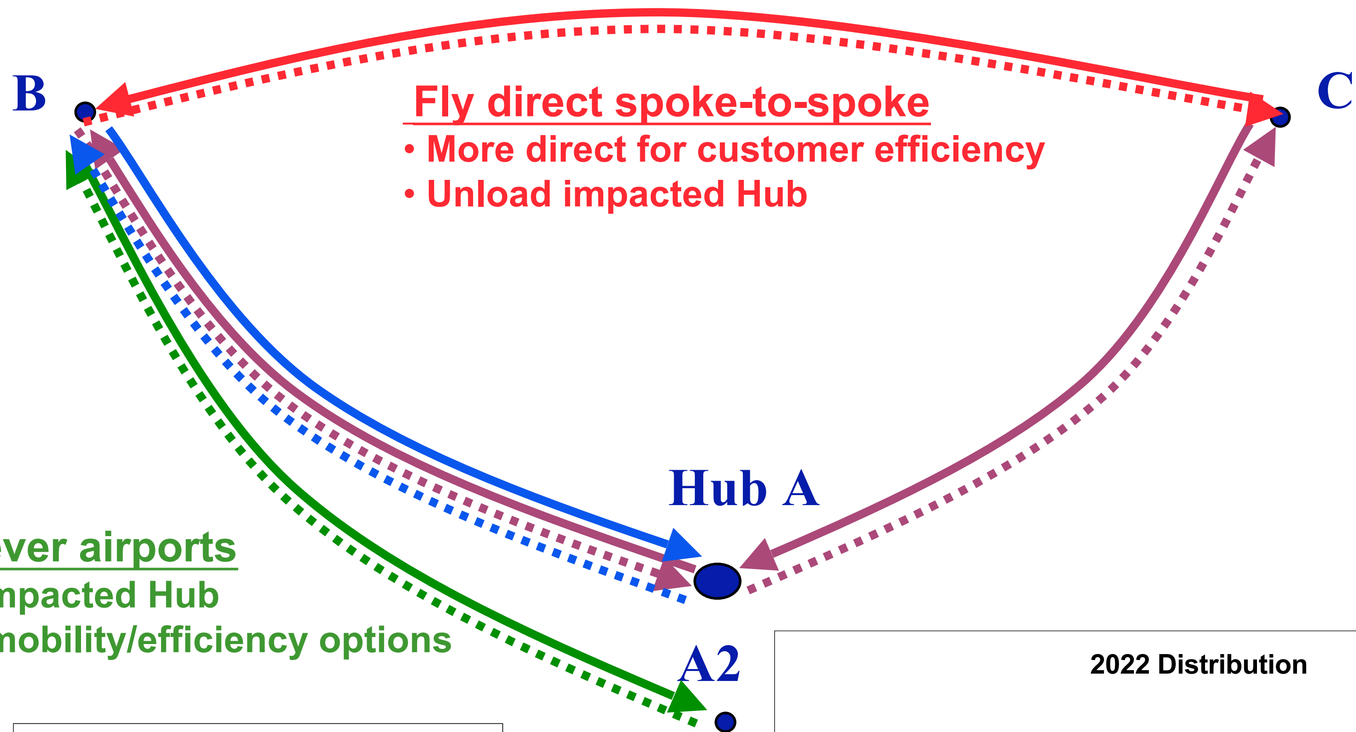
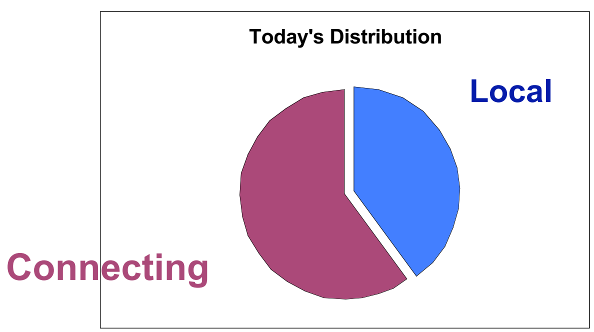
Concept PTP Capacity-Increasing Demand Mechanisms

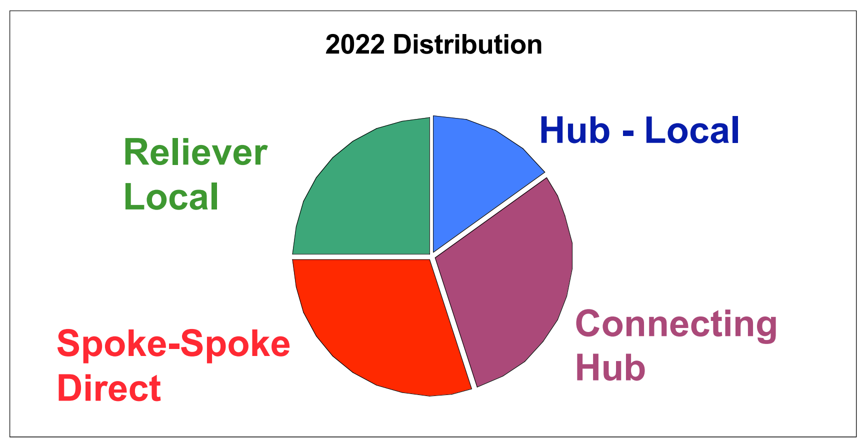
Point-to-Point Design Has Two Demand Mechanisms to Increase NAS Capacity:



Fly direct spoke-to-spoke
- More direct for customer efficiency
- Unload impacted Hub

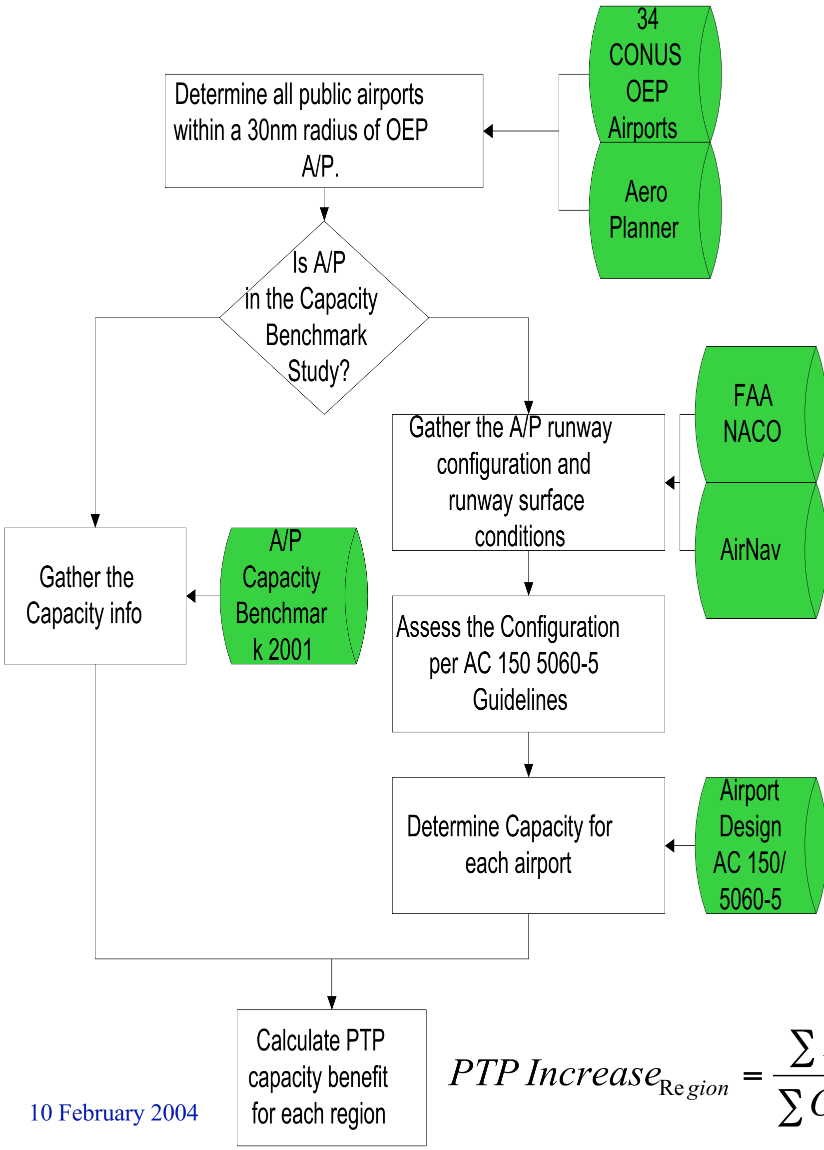
Use reliever airports
- Unload impacted Hub
- Provide mobility/efficiency options

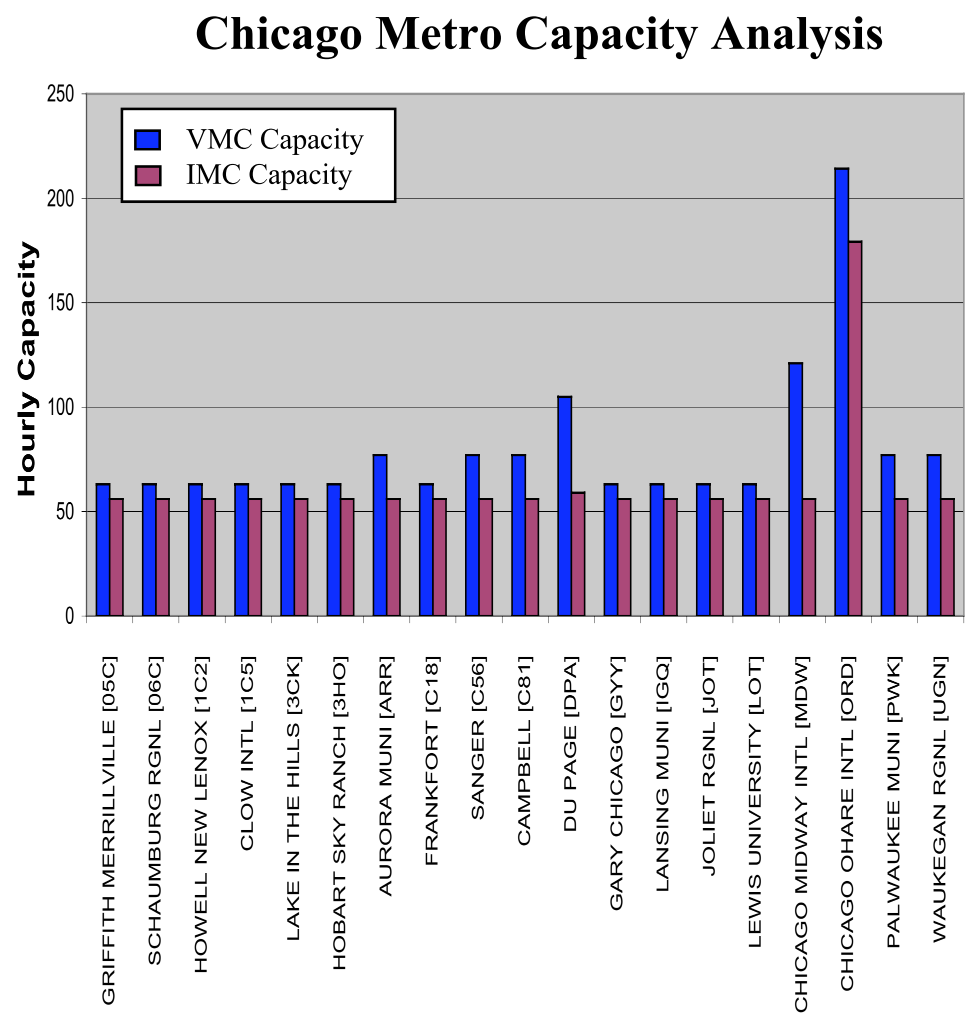




Process for Calculating NAS-wide PTP Capacity Benefits

- **Using Diversion of Demand to PTP Auxiliary Airports**



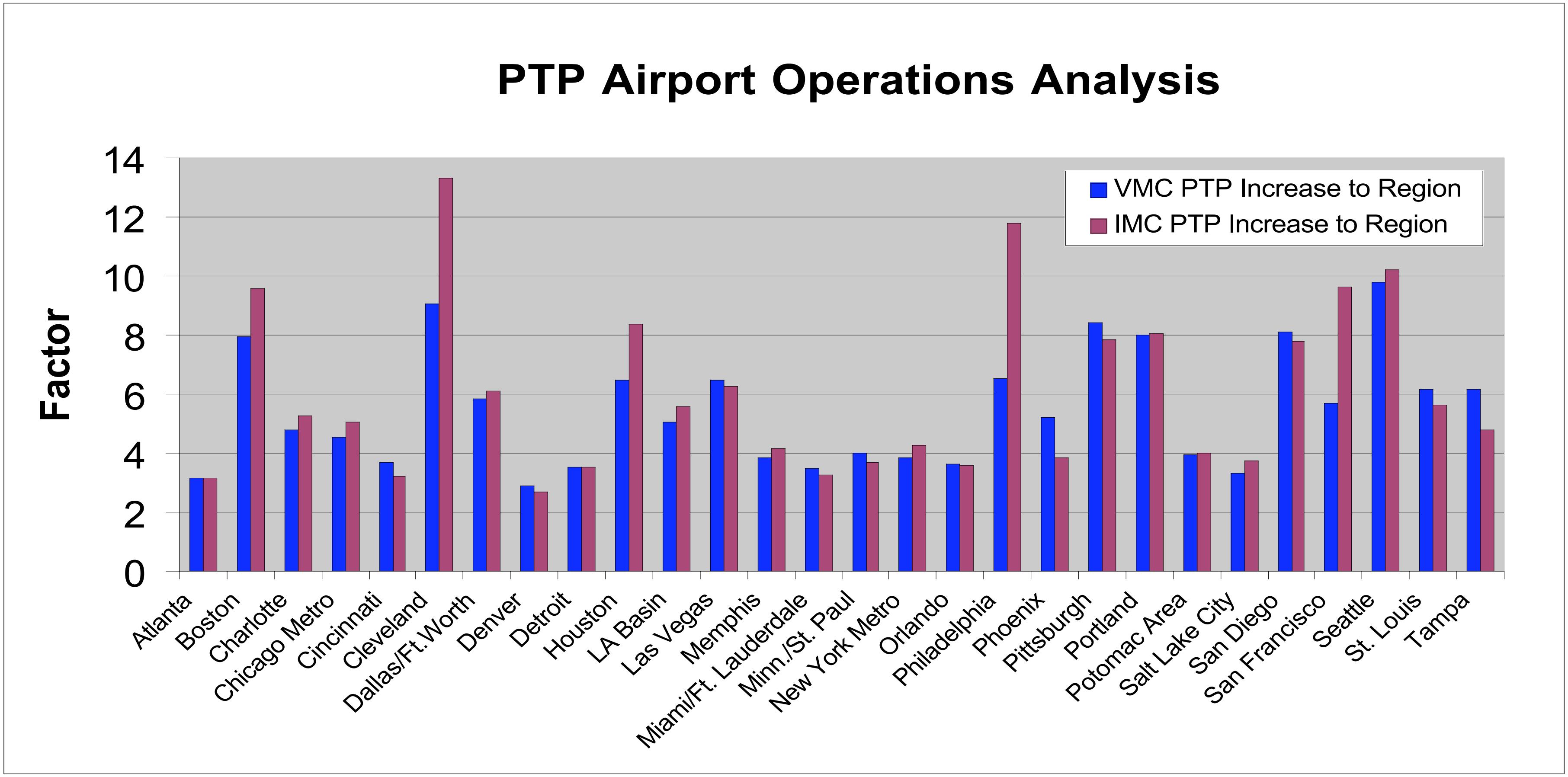


$$PTP\ Increase_{Region} = \frac{\sum All\ Airport\ Capacity_{Region}}{\sum OEP\ Airport\ Capacity_{Region}}$$

NAS-wide Benefit Results

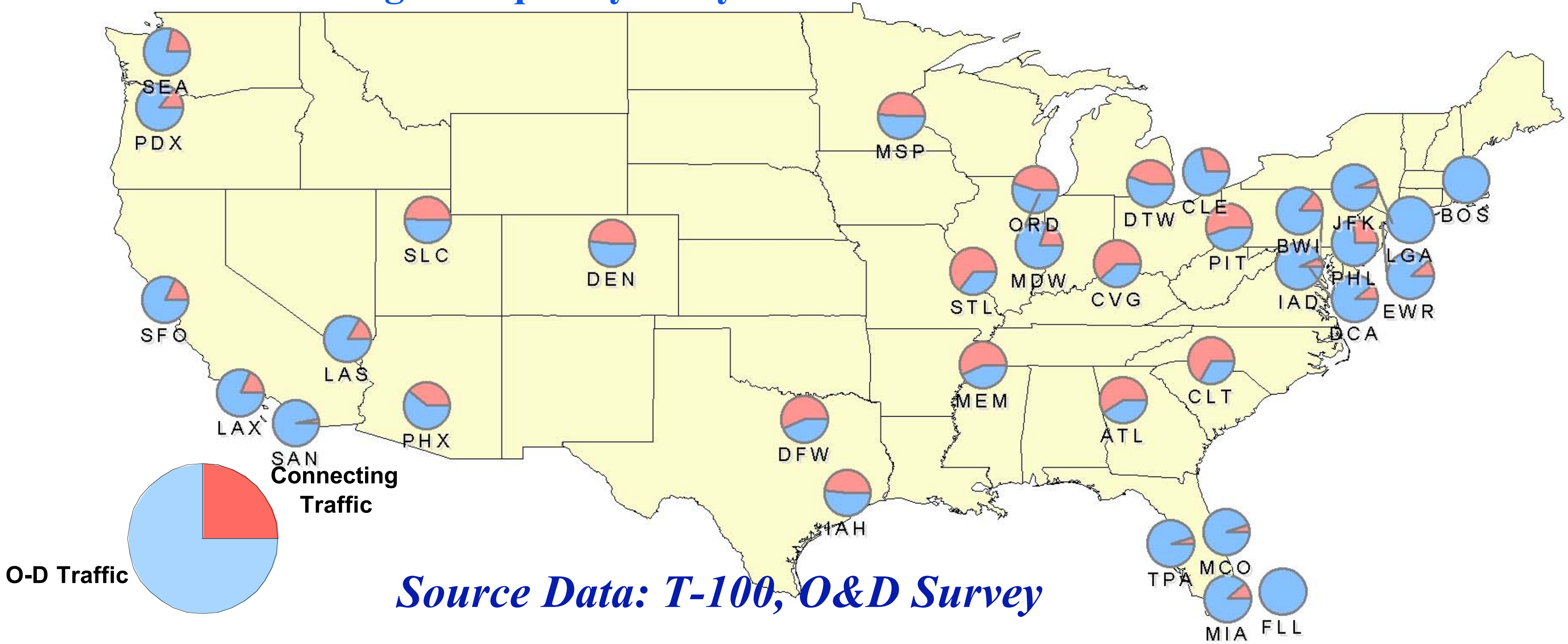
- **Using Diversion of CONUS OEP Demand to PTP Auxiliary Airports**

$$PTP\ Increase_{Region} = \frac{\sum All\ Airport\ Capacity_{Region}}{\sum OEP\ Airport\ Capacity_{Region}}$$



NAS-wide Benefit Results

- **PTP Reduction of CONUS OEP Hub Airport Domestic Connecting Traffic**
- **Potential reduction in domestic flight operations (see below)**
  - **Caveats:**
    - › **Data is upperbound**
    - › **Conversion of passenger traffic to flight ops reductions reqs further invest.**
    - › **Larger connecting vs. point-to-point fleet mix will mitigate benefit**
    - › **Lower flight frequency likely to reduce demand**



Source Data: T-100, O&D Survey

Challenges

- **Chicago Area-to-NAS representation**
- **Importance of NAS-wide interactions**
- **Predicting Airport Demand-Capacity Coupling**
- **Constructing typical weather scenarios**
- **How far do we go in terms of extending our economic impact analysis beyond the work described above?**
- **Five additional areas we want to explore include:**
  1) Evaluating performance during "typical annual" and bad Wx days,
  2) Performing NAS-wide auxiliary airport system simulations,
  3) Creating NAS-wide direct, PTP flight demands and performing NAS-wide simulations,
  4) Determining revenue implications of new demand scenarios, and
  5) Extending the analysis to other Concept PTP core ideas such as Terminal and En route

PTP Self-Assessment Results Summary

- **Technical Feasibility:**
  - A highly-detailed PTP System Description has been created
  - Work is in-progress to define a detailed Terminal Model required to test PTP's most challenging domain
- **Operational Feasibility:**
  - Many PTP human factors issues have been identified
  - A Subject Matter Expert survey of pilots, dispatchers, and controllers has revealed bullish Concept PTP sentiments from pilots and more conservative sentiments from controllers and dispatchers
- **Economic Impact:**
  - A study of the Chicago Metro Area has revealed significant potential PTP capacity improvements beyond FAA's 2013 OEP capacity
    - These benefits are cost-effective, but put the majority of PTP system costs on the airlines through increased aircraft expenditures
  - Assessments suggest significant PTP NAS capacity improvements through the use of:
    - Auxiliary airports around OEP airports and
    - Potential offloading of hub connecting traffic through more directs
- ***Concept PTP Design and Evaluation Work is On-going***

Background Slides

Payload and Aircraft Capacity Needs

- **Growth in air transportation demand creates corresponding problems: lack of hub airport and airspace capacity**
  - VAMS assumption: 4.2% annual RPM growth doubles demand in 20 years (i.e., 100% growth in required payload capacity).
  - NASA Aeronautics Blueprint: “Number of domestic commercial travelers is expected to double in 10 years and triple in 20 years.”
  - ATCA Conference panel: “We should plan for a 300% to 500% increase in number of aircraft flying in the NAS within the next 25 years.”
- **Assumption: Need capacity to transport 300% of today’s payload**
  - 150% handled by throughput improvements at hub/large spoke airports
    - › **With 150% of today’s commercial aircraft (average 150 passengers/aircraft)**
  - 150% handled by using auxiliary (reliever) airports
    - › **With 300% in number of smaller aircraft (average 75 passengers/aircraft)**
  - Additional 50% in number of aircraft to include micro-jets, UAVs, and rotorcraft, many operating at more remote airports
- **Resulting assumption is 500% increase in number of aircraft operating (aircraft capacity demand)**

Assumed Aircraft Equipage Types

Legend

- A — Type B + AOP
- B — ADS-B, ADL, 4D FMS, RTSP, TIS-B, FIS-B
- C — No Additional Requirements

Free Flight Airspace	≥FL350	FC Responsibility: Self Separation, Adherence to TFM Initiatives, Maintain 4D UPT ATC Responsibility: Monitor Compliance	
	<FL350 ≥FL270	FC Responsibility: Self Separation, Adherence to TFM Initiatives, Maintain 4D UPT ATC Responsibility: Monitor Compliance	FC Responsibility: Negotiate 4D UT, Maintain Envelope ATC Responsibility: Separation, Negotiate 4D UT, Adherence to TFM Initiatives
Transition Airspace	<FL270 ≥FL180	FC Responsibility: Negotiate 4D UT, Maintain Envelope ATC Responsibility: Separation, Negotiate 4D UT, Adherence to TFM Initiatives	FC Responsibility: Maintain 3D Route Envelope ATC Responsibility: Separation, 4D Advisories, Adherence to TFM Initiatives
	<FL180	FC Responsibility: Negotiate 4D UT, Maintain Envelope ATC Responsibility: Separation, Negotiate 4D UT, Adherence to TFM Initiatives	FC Responsibility: Maintain 3D Route Envelope ATC Responsibility: Separation, 4D Advisories, Adherence to TFM Initiatives

Technology Requirement: Airport ATM Automation R&D

Smart Airport Automation System (SAASY) project:

Required Aircraft Equipage: VFR Focus – VHF radio, ADS-B, 2-way ADL and CDTI optional
Project Outcome/Status: Conducted flight tests at NASA Moffett Field in 2002
Advisories worked well, but needs human factors improvement

Related Work:

- NASA Langley SATS Airport Management Module (AMM) – IFR Focus
- Provides automated sequence advisories
- Uses 2-way Pilot-ATC, Pilot-AMM information exchange
- AMM Software being integrated into CNS hardware to support FY04/05 flight tests at SATSLab field test sites

Ref: Schleicher, D. et al, "Past, Present, and Future of Small Airport Automation," 2003 AIAA ATIO Conf.

Human Performance Requirements

CORE IDEAS

- Human factors will be key to PTP success
  - Pilots, ATCSs, and Operations
- Human-system interface
- Ease-of-use and perception of difficulty
- Perception of safety

Human Performance Requirements

ANTICIPATED BENEFITS

- Better design
- Refine Core Concept based on user input
- Streamline technology interoperability
- Continue to define roles and responsibilities
- Reduce training requirements
- Improved safety
- Improved system efficiency

Human Performance Requirements

METRICS

- Professional analysis
- Questionnaire results from potential users

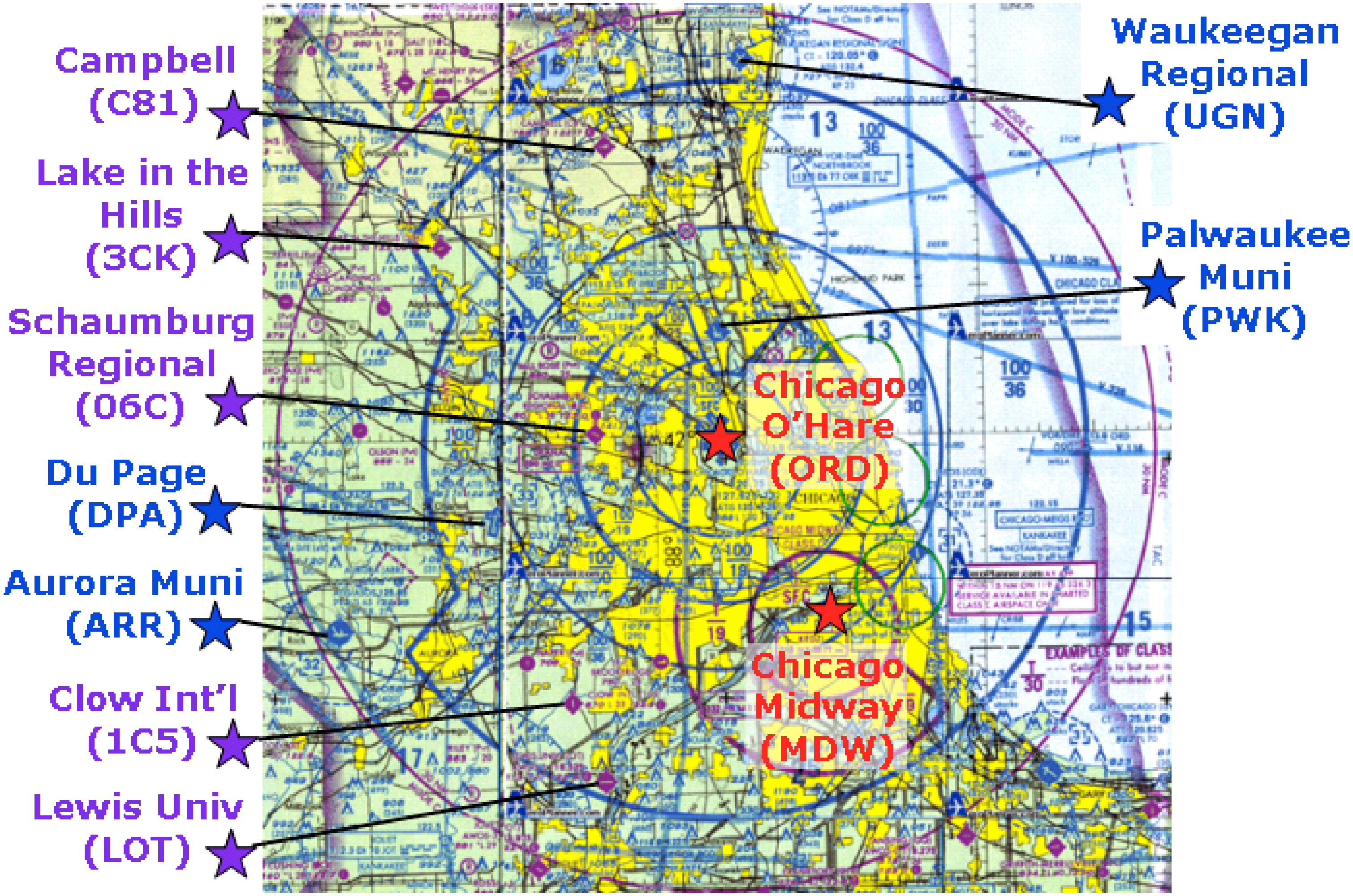
Human Performance Requirements

Results and Further Concept Description

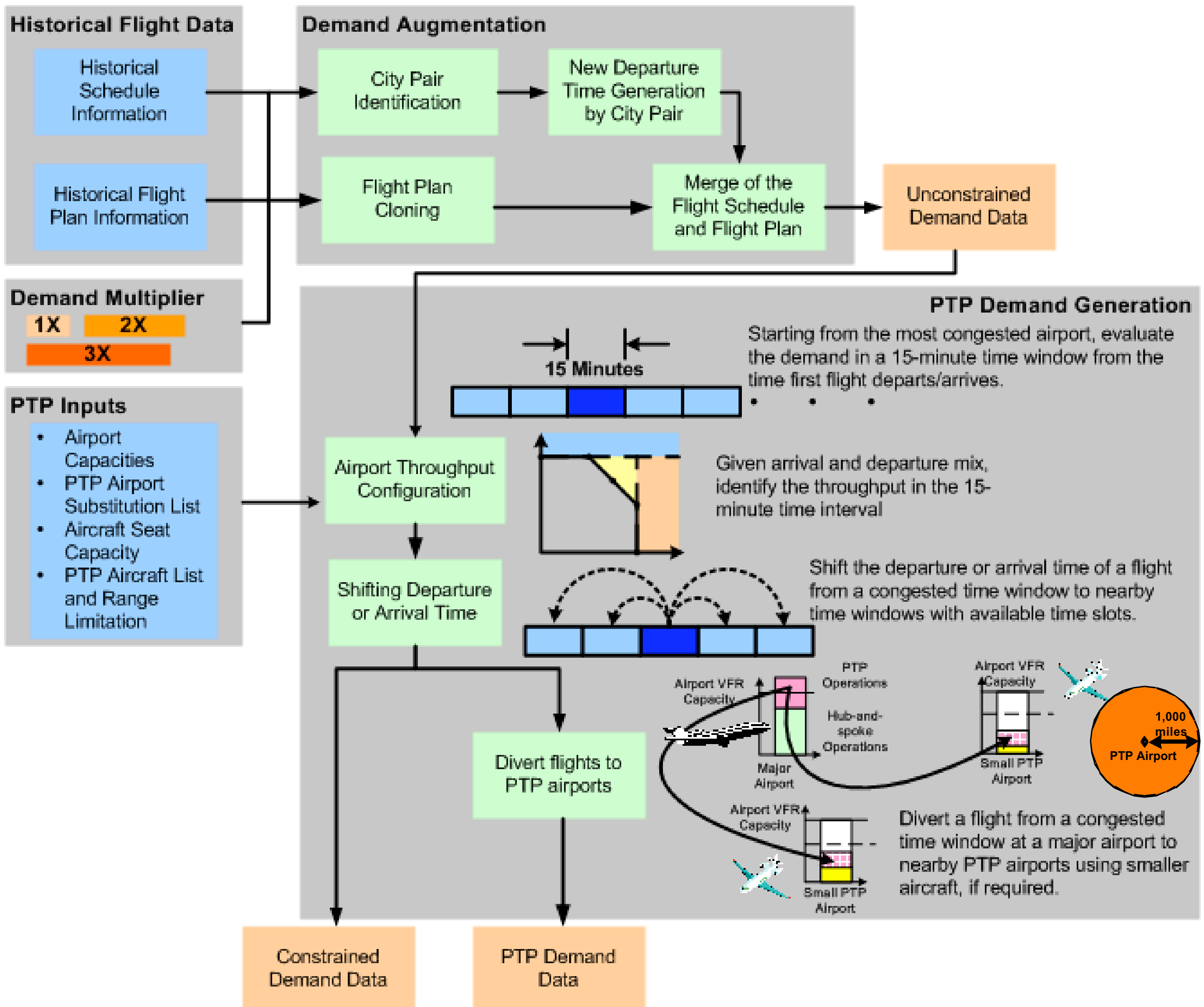
- Shows support for Concept PTP
- Helps to narrow focus
- Further analysis of suspect areas
- Identify & observe similar operations

Approach: *Scope*

- **Chicago Metro Area**
  - **ORD: #2 in total CY2000 ops, enplanements, and delays**

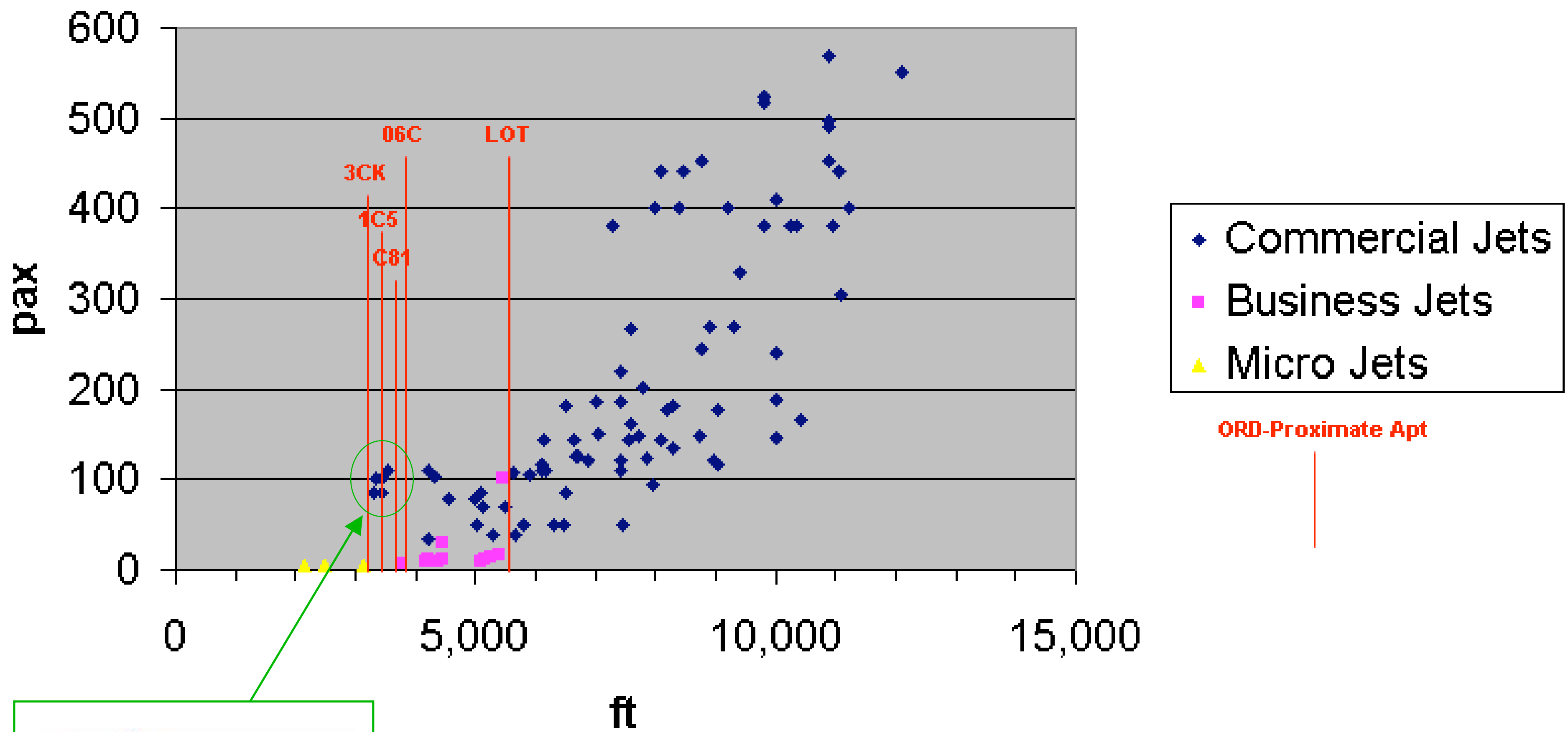


Approach:
Demand Generation



Takeoff Field Length vs. Number of Passengers

Source: *AvWeek Aerospace Source Book 2002*

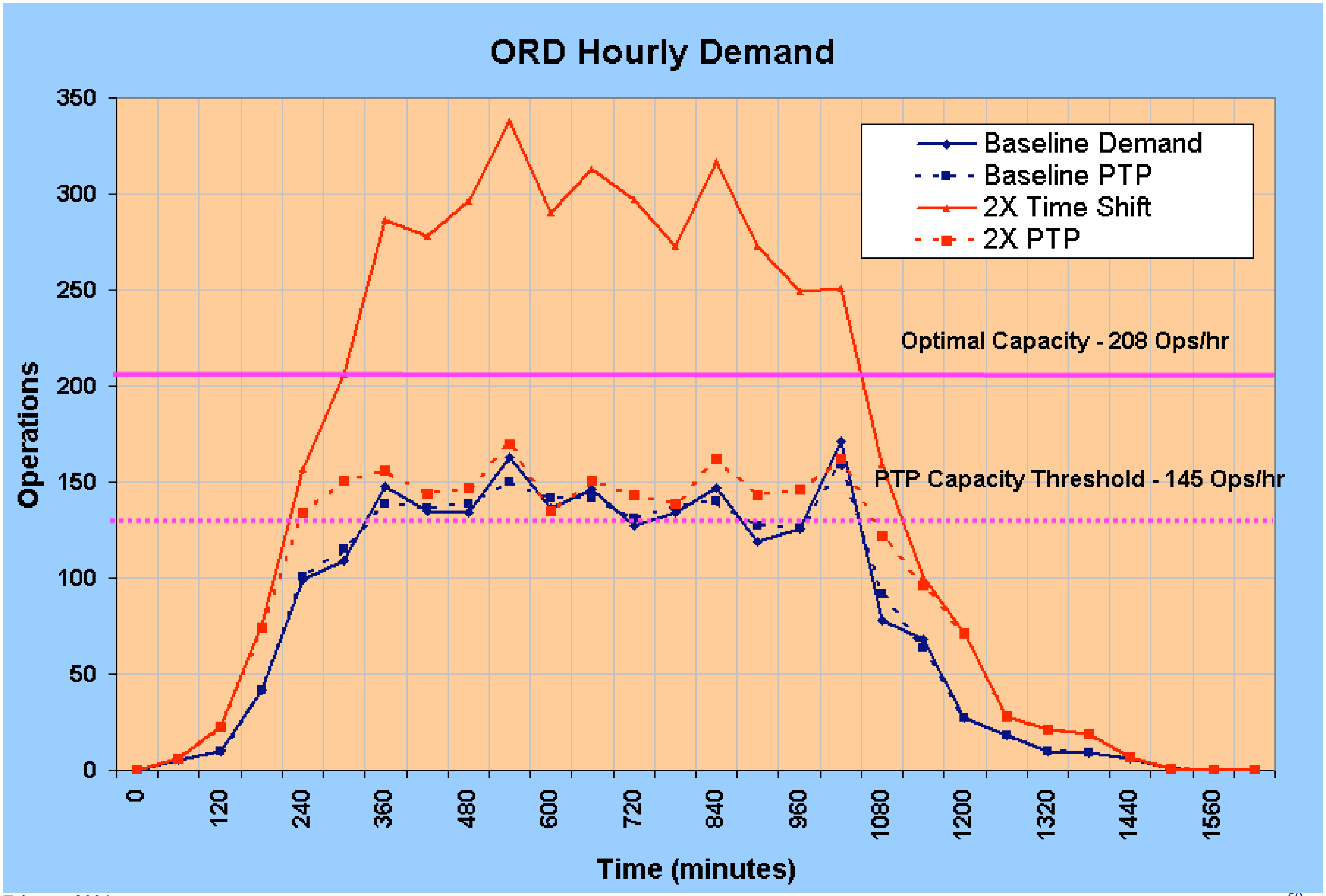


- **BAe 146-100/200**
- **Avro RJ70/85/100**

PTP Demand Scenarios

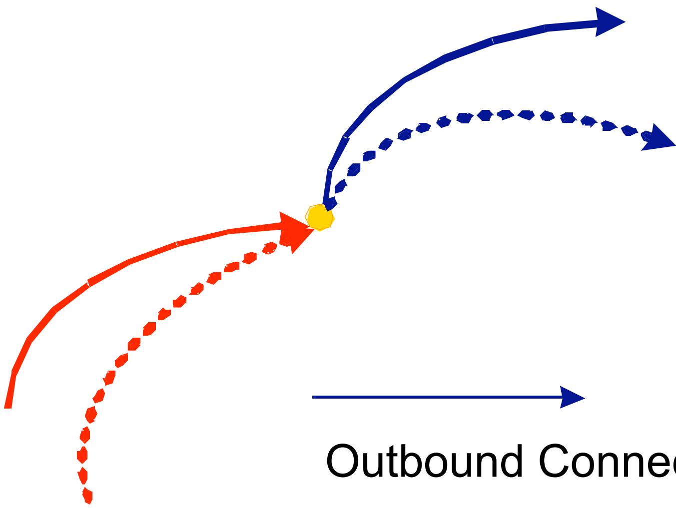
Demand Scenario	Demand Source	Shift Departure/Arrival Time	Use PTP Airports
Baseline Demand	May 17, 2002		
Baseline Time Shift	May 17, 2002	✓	
Baseline PTP	May 17, 2002	✓	✓
2X Demand	2x May 17, 2002		
2X Time Shift	2x May 17, 2002	✓	
2X PTP	2x May 17, 2002	✓	✓

Baseline ORD Demand Output



Major Hub Airport Connecting Passenger Analysis

- **Focus:**
  - **PTP-based reduction of Hub Airport Domestic Connecting Traffic**



T-100 Flight Segment Data (Monthly Data)

Contains both Inbound and Outbound connecting and O-D Traffic at an Airport

10% Origin-Destination Survey Data (Quarterly Data)

Contains Inbound and Outbound O-D Traffic at an Airport

Outbound Connecting Passengers

Inbound Connecting Passengers

Outbound O-D Passengers

Inbound O-D Passengers